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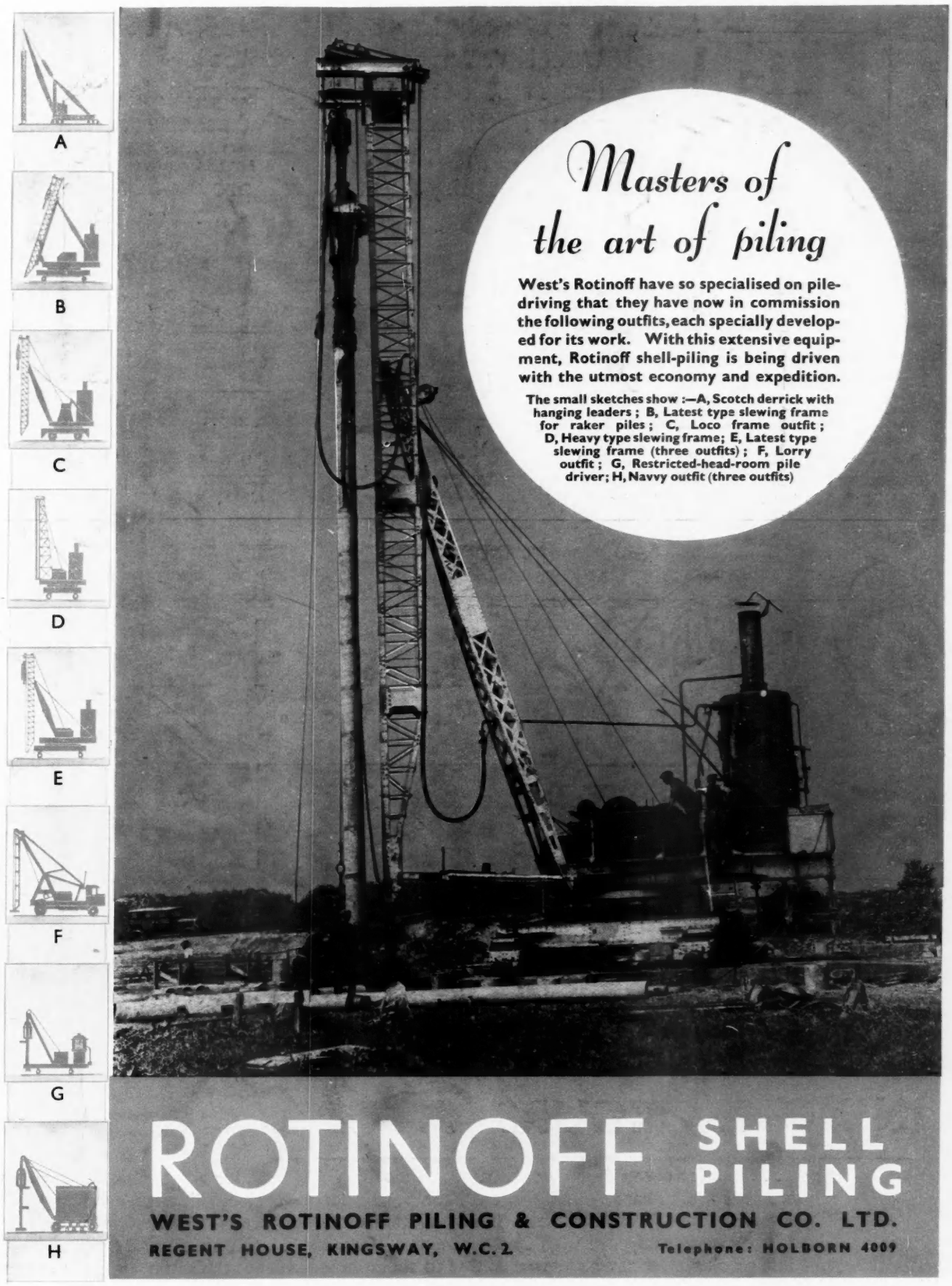
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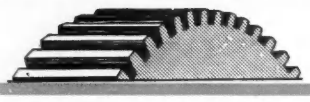

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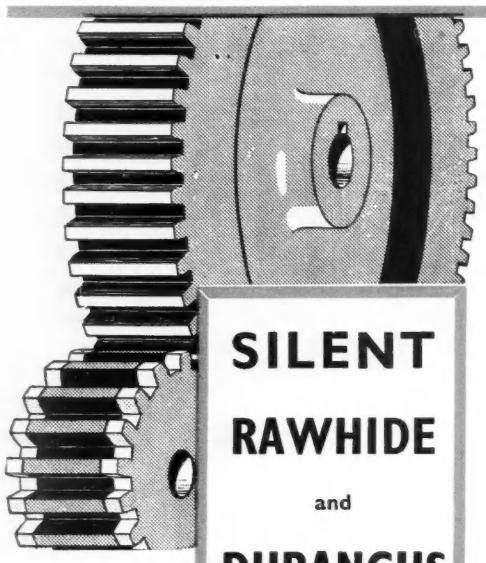

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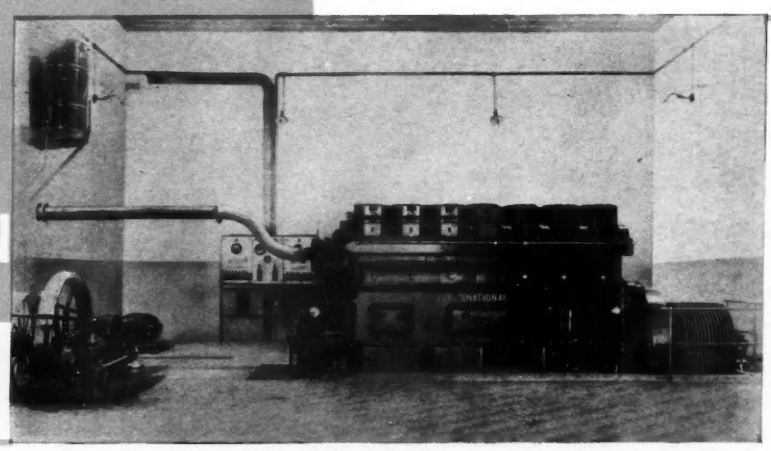

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A Seven-Day Journal

Electrical Extensions on the Southern Railway.

Two more electrified lines were brought into service by the Southern Railway on Monday, September 30th: (1) the loop at Lewisham Junction, connecting the Charing Cross-Dartford line with that from Victoria and St. Paul's to Nunhead and Catford; and (2) the line from Woodside to Sanderstead *viâ* Addiscombe and Selsdon. Although the length of the former line is only 1½ route miles and that of the latter 3 miles, the effect on traffic will be great. Electrification of the loop between Lewisham and Nunhead makes it possible to run electric trains from the Bexley Heath and Dartford loop lines into St. Paul's Station, thus relieving the pressure of the services to and from Charing Cross and Cannon-street. These special services are being operated during the morning and evening rush hours and also on Saturday mornings and at mid-day. The first train from the Bexley Heath line will arrive at St. Paul's at 7.50 a.m. and from the Dartford loop line at 8 a.m. In the homeward direction the first train from St. Paul's to the Bexley Heath line will leave at 5 p.m. and from the Dartford loop line at 5.20 p.m. On Saturdays the first train from St. Paul's to Dartford will leave at 12.1 p.m. and to Bexley Heath at 12.21 p.m. On the Woodside and Sanderstead section there will be approximately a half-hourly service to and from Charing Cross and Cannon-street, with additional trains during the rush hours. Two new stations are being brought into use on this line, *i.e.*, Coombe-road and Bingham-road, which are situated between Addiscombe and Selsdon. The approximate cost of these extensions is £233,000.

A New Tyne Tunnel Scheme.

At a joint conference of representatives of the Tyne Crossing Sub-committees of the South Shields and the Tynemouth Corporations, which took place at South Shields on Tuesday, September 24th, it was decided to recommend a specific tunnel scheme to two special meetings of the two Councils, which are to be held within the next fortnight. The scheme has been prepared by Messrs. Mott, Hay, and Anderson, consulting engineers, of Westminster, and the original estimate is stated to be about £1,240,000. At the meetings to be held details will be discussed of the tunnel scheme and also of such items as its maintenance and lighting and the necessary road widening operations which must accompany it. The object of the meetings will be to enable the two Councils to submit jointly to the Ministry of Transport an agreed concrete scheme for the purposes of ascertaining what grant towards its cost the Ministry is prepared to make. There seems to be a unanimous opinion that a tunnel is necessary to supersede the existing ferry services.

The Late Mr. Wilfred Holmes.

Many of our readers will learn with regret of the death, on Saturday last, September 28th, of Mr. Wilfred Holmes, the manager of the instrument department of Ferranti, Ltd., of Hollinwood, Lancashire. Mr. Holmes, who earlier in the year recovered from a serious illness, was only fifty-eight years of age and for more than thirty years had been a member of the Ferranti staff. He was a trusted assistant and a personal friend of the late Dr. Z. de Ferranti, under whose guidance he carried out extensive and invaluable work on the subjects of meters, instruments, and kindred apparatus. For many years he has been accepted as an authority on metering problems, and he made frequent contributions on the subject in papers which he read before the Institution of Electrical Engineers and in articles he contributed to the technical Press. He also served on several committees of the British Standards Institution. From its inception the Meter and Instrument Section of the I.E.E. found in him one of its most active members, and this year it paid him the honour of electing him Chairman for the coming session. Wilfred Holmes was gifted with a great personal charm, lightly veiled, perhaps, with an inborn shyness which he never really overcame. His appreciative understanding of the younger members of his staff enabled him to bring out the best in all who worked for him, and to-day there are many prominent meter engineers who readily acknowledge how much they owe to the kindly patience which he showed to them during their early training.

Road Research.

On Monday, September 30th, the Department of Scientific and Industrial Research issued the first report of its Road Research Board, covering the two years ended March 31st, 1935, during which the Department has assumed responsibility for the researches on roads carried out at the Road Research Laboratory, Harmondsworth, Middlesex. The report states that arrangements have been made which will secure the fullest measure of technical co-operation between the Department of Scientific and Industrial Research in its conduct of the work carried out at the Road Research Laboratory and the Ministry of Transport, which continues to be responsible for experimental work under normal traffic conditions. A good beginning has been made on a very comprehensive programme of research, which is described in the report. The need for such a programme is based on the cost of making and maintaining the roads of Great Britain, which is given at upwards of £50,000,000 a year, and on the still more urgent problem of road safety. In this connection attention is being given to the problem of skidding. The work aims at the determination of the factors in vehicle design which induce skidding and the investigation of the factors in road construction and conditions which are favourable to skidding, and must therefore be avoided. In addition to safety, the problem of wear due to different types of vehicle and their effect on impact forces is being investigated with the co-operation of the Research Committee of the Institution of Automobile Engineers and of certain manufacturers. Co-operative research has also been arranged with the British Road Tar Research Association.

Conway Bridge Condemned.

The announcement is made that Thomas Telford's suspension bridge over the river Conway, which was constructed in 1826 at a cost of £10,000, has been condemned by the Ministry of Transport. The proposal is to build another bridge, which will be free from toll, at a cost of about £75,000. While the Telford bridge, which served as a model for the Menai Suspension Bridge, is not in any immediate danger, it is felt that it cannot be left to bear the enormous burden to which it has been subjected during recent years. It only allows one-way traffic, and it is strongly felt that a new structure providing for two lines of traffic is urgently needed. Nevertheless, the Bridge Commissioners of the Conway Borough Council were reluctant to end the days of the old bridge, and various schemes for retaining it were discussed with the Ministry of Transport. The scheme which has been adopted provides for the destruction of the old bridge and the building of a new one, with provision for two lines of traffic. It also provides for the widening of the main road through the town and the demolition of some ancient buildings. It may be recalled that the Conway Bridge has a span between towers of 327ft. There are four eye-bar chains on either side, each composed of links 3½in. by 1in. and 9ft. long. The chains lie vertically above one another, but are not connected, and have a centre sag of about 22ft. In 1904—see The Engineer of May 20th, 1904—new anchorages were made, and two new cables on each side were added, with new suspension links, and 8½in. deep stiffening girders, while a new 6ft. footway was also built on the north side, at a total cost for the whole renovation work of about £6500.

Sea Trials of H.M.A.S. Sydney.

The 7000-ton displacement cruiser "Sydney," recently completed by Swan, Hunter and Wigham Richardson, Ltd., for His Majesty's Royal Australian Navy, was launched on September 24th, 1934, and has now been handed over. The length of the "Sydney" is 530ft. between perpendiculars and her beam is 56ft. 8in. In general design and equipment she belongs to the modified "Leander" class, 1932 programme. She has two quadruple torpedo tube mountings, eight 6in. guns in twin mountings, four 4in. guns and other guns of smaller calibre, and carries amidships a catapult for launching seaplanes. Her main propelling machinery comprises a four-screw arrangement of geared turbines with a total output of 72,000 s.h.p., steam being raised in oil-fired water-tube boilers. Both the turbines and the boilers were constructed by the Wallsend Slipway and Engineering Company, Ltd., at Wallsend. The "Sydney" has just completed a series of exhaustive trials at sea, some of which were run off the mouth of the river Tyne, while others took place in deep water on the measured mile off St. Abb's Head. The trials included a series of runs at various powers, circle-turning trials, gun trials, capstan and anchor trials, and consumption trials, all of which were, we are informed, completed successfully.

The New Leek Pumping Station.

On Thursday, October 3rd, the new Poolend pumping station of the Leek Urban District Council was formally opened and inspected. The installation comprises an electrically driven bore-hole pump at Poolend, about 1½ miles north-west of Leek. The scheme has been designed and carried out by Messrs. Herbert Lapworth Partners, of Westminster, in collaboration with Mr. W. E. Beacham, M. Inst. C.E., the Council's water engineer. The bore-hole, which was sunk into the Bunter sandstone beds by Le Grand, Sutcliff and Gell, Ltd., of Southall, was carried to a total depth of 400ft. The upper part of the bore-hole is lined with plain 36in. tubing for 72ft. 7in. and thereafter to a depth of 320ft. 6in. below the surface with 33in. diameter perforated tubes, with a 79ft. 6in., 30in. diameter bottom unlined. For fifteen days 41,000 gallons per hour were pumped continuously, lowering the water level from 34ft. to 41ft. 3in. below the surface. The pumping plant comprises a Mirrlees Watson bore-hole pump placed 70ft. below the engine-house floor. The installation is complete with motor and control gear, and the 10,000-volt supply of the Council's Electricity Department is transformed to 400 volts for power, lighting and heating. The plant is fully automatic and can be set to pump for a given time and then shut down. The normal duty is 30,000 gallons per hour and the pumping main comprises a 2¾-mile length of 10in. Stanton spun pipe to the Mount Pleasant Reservoir. The water in this case is delivered under 341ft. total head. Alternatively the plant can supply 20,100 gallons per hour to the Kniveden Reservoir against a total head of 426ft. The plant is housed in a brick building equipped with a 5-ton crane.

The Naval Construction Programme.

In accordance with normal practice at this time of year, the Admiralty has begun to call for tenders for the twenty-one ships comprised in the Naval Construction Programme for 1935. They will consist of three cruisers, the expenditure on which under this programme, it is estimated, will amount to some £5,000,000; eight destroyers, estimated to require about £3,000,000; one flotilla leader, three submarines, one submarine depôt ship, four sloops, and one surveying ship. In addition, several small vessels are included in the programme. On these estimated figures, £10,000,000 is considered to be the probable cost of the programme. The preparation of contracts and tenders will probably take up till February next, but work should be in hand by next spring. Some of the ships will be built in the Royal Dockyards, so that it is difficult to estimate the number of men likely to find employment until the orders placed with the different firms are known. It is expected on the Clyde that local shipyards will benefit materially in the allocation, an order for at least one cruiser, in addition to smaller craft and machinery, being looked for. For nine months of the present year the output of the Clyde yards is represented by seven vessels, of 126,897 tons total. During September only five vessels, totalling 8200 tons, were ordered. In the corresponding period of last year the figures were seventy-seven vessels, of 165,096 tons total.

A Submarine Cable Amalgamation.

On Monday, September 30th, the amalgamation was announced of the submarine cable interests of the Telegraph Construction and Maintenance Company and of Siemens Brothers, Ltd. This step has been decided on chiefly owing to the progress of wireless transmission, which has taken away the monopoly of the submarine cable as a means of oversea transmission, while the reduction of international trade has caused a decrease in the volume of telegraphic business. The two companies have formed a new company under the title of Submarine Cables, Ltd., which is to take over the manufacture of all submarine cables. It is believed that by concentrating manufacture in one modern factory and by having only one organisation to maintain instead of two, considerable reduction will be made in overhead expenses. The new company will have a capital of £220,000, owned in equal shares by the two founder companies. The East Greenwich works of the Telegraph Construction and Maintenance Company are to be leased by the new company, the board of which is composed as follows:—Mr. Colin F. Campbell (chairman), Sir Geoffrey Clarke (managing director), General Sir Hubert Gough, Lord Queenborough, Lord Riverdale, and Dr. H. R. Wright. The directors are fully satisfied that the concentration will be a decided advantage to the shareholders, as well as to users of submarine cables all over the world.

The Late Mr. Geoffrey Porter.

Electric supply engineering has lost a leading exponent by the death of Mr. Geoffrey Porter, which took place at Worthing on Thursday last, September 26th. For the past thirty-five years Mr. Porter served the Borough of Worthing as its Electrical Engineer, joining the undertaking in 1901, when the area of supply was a little over 1425 acres, the population some 20,000, and the capital expenditure £32,500. Largely owing to his initiative and capacity, the area of supply has been increased to 26,000 acres, and the number of units sold has risen from 200,000 to 11,000,000. An early user of oil engines, Mr. Porter was a founder member of the Diesel Engine Users Association, and in June, 1916, he read his first paper to that Association, on "Oil Engines and Steam Engines in Combination." In succeeding years he dealt ably in other papers with the problems of tar oil fuels, notes on the wear of Diesel engines, connecting-rod bolt problems, and generally with the functions of the oil engine in electricity supply and the choice of sites and the lay-out of stations. When the South-East England grid scheme was adopted he loyally assisted in carrying out its provisions. Mr. Porter was a member of the National Consultative Committee of the Central Electricity Board, and a past-President of the Diesel Engine Users Association and the Incorporated Municipal Electrical Association, also an associate member of the Institution of Civil Engineers.

Dynamometers for Agricultural Research.

By J. S. WILSON, M.A., B.Sc., A. Inst. P.*

No. I.

Introduction.

WHEELED transport, although in use in this country for centuries, became increasingly important at the end of the eighteenth and beginning of the nineteenth centuries, as the growth of the manufacturing industries made necessary the transport of goods and workers to a greater extent than ever before.

Light traffic was generally confined to the roads and the heavier goods were water-borne, as this was the only possible method by which they could be moved. Experience had shown that it was far easier to pull a ton of material when floating in water than when it was in a wheeled vehicle on the road, and this discovery and its application is at the commencement of the study of dynamometry. As early as 1803 scientific experiments were carried out to compare the rolling resistance of different types of wheeled carriages on roads, and since that time there has been continual progress, both in the design of carriage and in the nature of the surface on which it travelled, with a view to decreasing draught, *e.g.*, by the introduction of tram rails for horse-drawn vehicles.

In the earliest research on this problem it was only possible to obtain a measure of the resistance to motion by seeing what was the greatest load on the particular vehicle which a given horse could pull; but Gen. Morin[1] carried out experiments with a dynamometer using the extension of a spring to measure the pull on the vehicle. His type of apparatus survives in almost all the existing railway dynamometers, but it has not appeared suitable for application to dynamometers for agricultural work.

The early dynamometer work referred to above was almost entirely concerned with the reduction of the draught of vehicles which had to be hauled by one or more equal power units, *i.e.*, horses. A decrease in the draught meant that it was possible to carry a greater pay load. When, however, dynamometer research is applied to agriculture, the problem is entirely different. Haulage of carts, &c., is of secondary importance only, and the fundamental work which falls to any power haulage unit is that of operating the cultivating machinery. In ploughing, for instance, the draught per furrow is high (500–1000 lb. wt), as compared with the draught of road vehicles, and on given land under normal ploughing conditions is not likely to be much altered by altering plough design, so long as the quality of the work is unimpaired. In fact, the draught is almost entirely determined by the physical and mechanical properties of the soil and the state of tilth which it is required to produce. Dynamometry in agriculture is therefore more concerned with the study of the power output from the prime mover than with the measurement of the draught of the implement towed.

Thus, it is that such work was only seriously undertaken with the appearance in common use of the internal combustion engined agricultural tractor.

Trials of these machines were carried out in this country in 1919 at Lincoln[2] when the Hyatt and N.P.L. dynamometers were used, both of them employing an oil-pressure method of measuring the draw-bar pull; the N.P.L. dynamometer was also used at the R.A.S.E. trials in 1920,[3] while for those held in 1921 at Shrewsbury[4] the Watson dynamometer, also a hydraulic type, was employed. In 1928 Haines and Keen[5] introduced another dynamometer, which was specially designed for work with horse-drawn, as well as tractor-drawn, implements, but employing much the same principles as the others. Other agricultural dynamometers in use at the present day include those manufactured by Amsler and Polikeit, and it is the intention in this paper to discuss these on their merits and to describe also one or two forms of a type which has been developed at the Institute for Research in Agricultural Engineering and is used in its research work. The general problems involved in the design and application of the Institute dynamometer will be discussed in some detail.

The Dynamometer.

A dynamometer is an instrument for measuring work or power and, in general, this resolves itself into the independent measurement of the force and the distance through which it moves the point of application or the speed with which the point is moved. The only way in which work can be measured by observation of one variable is by the conversion of the work into heat, and this is a method of rather limited application.

Dynamometers fall into two classes, (1) those which measure the power by absorbing it and converting it to some other form of energy, and (2) those which measure the energy while transmitting to an external absorber of power. The simplest form of the first or absorption type is that of a weight hanging over a pulley where the change in position of the weight in a given time is a measure of the power absorbed; this type also includes the water and electric generator brakes. The second or transmission type is employed, for example, in work on power transmission in ship's propeller shafts, *i.e.*, a torquemeter, the power being transmitted by the shaft which forms part of the instrument and being absorbed by the interaction of the propeller and water.

Almost all traction dynamometers are of the transmission type, from the early instrument of Morin to the railway dynamometer cars and the instruments used in tractor testing. The many difficulties introduced by the draught of the vehicle carrying the absorption apparatus, together with the power losses in the drive to such apparatus, have made it usual to take the readings from a transmission-type instrument, even when it would be possible to compute the power from readings of current and voltage in an electric loading car employed to absorb the power output.

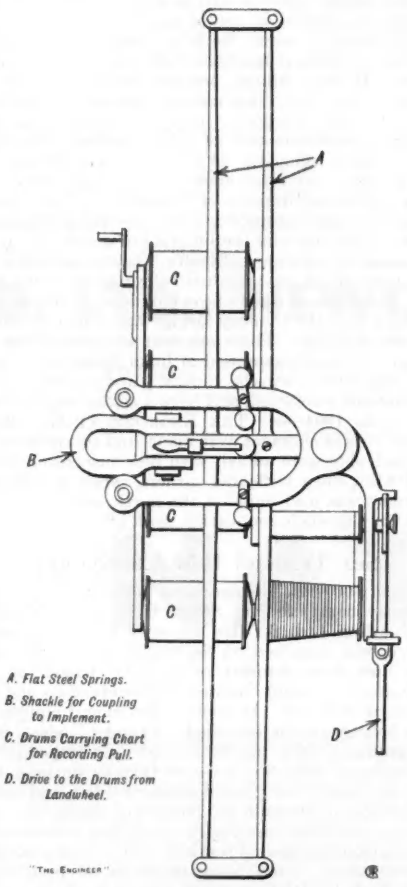


FIG. 1—MORIN'S DYNAMOMETER

Measurement of the Tractive Force.

Traction dynamometers are therefore essentially instruments capable of measuring (1) the pull or force exerted by the prime mover (or the force required to move a vehicle or implement), and (2) the speed at which the point of application of the force is moved. In general, these two variables are measured independently, and certain of the existing dynamometers employ a means of combining the two readings to give directly an indication of the power developed. The measurement of the pull (referred to as draw-bar pull) presents the more serious difficulty in traction dynamometry, and the instrument which measures this is often referred to as "the dynamometer." Two fundamental methods are available for measuring the pull. The simpler way is by the extension produced in a piece of elastic material, and this usually takes the form of a spring; the simple spring balance is a dynamometer of this type, and other examples will be discussed later. These dynamometers have no time lag and follow all the variations in the pull, with the result that they give a very rapidly fluctuating reading or a very jagged record, which is difficult to interpret. The second type employs a cylinder full of liquid and a plunger to convert the pull into pressure, which is then indicated or recorded by one of the standard methods. The damping in this type is considerable and varies with the liquid used and the bore of the connecting pipes, but it enables a more steady reading and a more even record to be obtained. The relative values of the two types of record in computing the true value of the pull will be considered.

The former type is more suitable and more generally used in railway dynamometry where resistance to motion of the load varies only slowly and the pull of the engine similarly is not subject to sudden variations. In agricultural work, where unevenness of the ground causes rapid fluctuations in the load and slip may cause rapid variations also in the effective pull of the tractor, the hydraulic type is the more useful.

The Measurement of Speed.

The measurement of speed in nearly every case is by means of the independent measurements of time and distance; revolutions of a standard diameter wheel and standard time intervals being recorded together on a chart. This method has certain limitations and in some work it is more satisfactory to determine the mean speed by direct timing of the passage of a given distance occupied by a test run.

The Dynamometer in Agriculture.

When cultivation was carried out largely by horses, measurement of the draught of implements was not attempted or even considered important—a heavier draught machine or a particularly heavy crop necessitated an additional horse and there could be no subdivision of these power units. With the application of the I.C.E. tractor to farming information was immediately needed as to (1) the horse-power developed, and (2) the fuel consumption per h.p. hour before a farmer could discriminate between the various machines. The tractor trials held in 1919–1921 were designed to provide information of this kind and dynamometers were designed specially for this work.

Requirements.

It will be well, before describing the various dynamometers developed for agricultural work, to set out the requirements which such instruments should fulfill. Primarily they must measure the draw-bar pull or draught; this may vary according to the nature of the test and the machines employed from 100 lb. to, say, 10,000 lb., and since this pull will vary throughout a run, arrangements must be made to integrate or record this pull. The speed must be measured and recorded or combined automatically with the pull to give a reading which is a direct measure of the horse-power. In addition, it will be an advantage if the following can be measured and recorded:—

The engine speed.
The revolutions of each drive wheel.
The fuel consumption.
The input to the tractor drive wheels.

Dynamometers will be considered under the two classes, those employing springs to measure the pull and those working on the hydraulic principle, and one or two special types will be referred to separately.

Types of Dynamometers: (1) Dynamometers Employing the Extension of Springs to Measure the Load.

Morin's Dynamometer, Fig. 1.—It consisted of two equal pieces of flat spring steel joined together by short bars at the ends so as to form a rectangle. The load was applied to the middle points of the two spring strips in a direction normal to the planes of the strips, and the relative displacement of the two mid-sections was indicated by a pointer attached to one spring and moving over a scale fastened to the other. Provision was made for winding a strip of paper past a pencil fixed to the pointer and so making a continuous record of the dynamometer readings throughout the run. Morin found that the displacement of the springs was proportional to the load until the displacement exceeded one-tenth the length of the spring strip.

Practically all the railway dynamometers are fundamentally similar to the Morin instrument, the springs being made up of a large number of parallel strips.

Regenier's Dynamometer.—Improved types of this simple form of dynamometer are many and the chief alteration has been in the shape and arrangement of the spring in an endeavour to produce a greater relative displacement of two parts of the spring for a given stress. Regenier introduced the elliptic spring, in which the load was applied at the ends of the major axis and the corresponding change in length of the minor axis was measured by a pointer and scale fastened to the spring, at the extremities of this axis respectively. Regenier also introduced a maximum indicating pointer. His dynamometer was designed specially for a comparison of the powers of men and animals.

Giddings' Dynamometer.—For comparative tests between the pull of traction engines and horses Giddings devised another similar instrument using a spring made of two semi-elliptic strips clamped together at the ends. A scale and pointer were arranged as in the previous type, with a maximum

* Institute for Research in Agricultural Engineering, Oxford University.

[1] "Notice sur divers appareils dynamométriques," Paris, 1841.

[2] Report of Lincoln Tractor Trials, S.M.M.T., 1919.

[3] Report, R.A.S.E. Tractor Trials, by R.A.S.E. and S.M.M.T., Aisthorpe, near Lincoln, 1920.

[4] Report, S.M.M.T. Tractor Trials, Shrawardine, near Shrewsbury, 1921.

[5] *Journ. Agric. Sci.*, 1928, 18, p. 724.

pointer and a slotted pointer arranged to give an average reading. In addition, the pointer carried a pencil, which made a record on a moving paper band driven either by clockwork or by the land wheels of the vehicle being tested. This was a distinct advance towards a truer horse-power meter, since the area under the record in a given time was directly proportional to "speed" times "pull," *i.e.*, to horse-power.

Modern dynamometers of this type are made in many forms by P. Polikeit, of Halle, and Schaffer and Budenburg, and are generally arranged with a land wheel for driving the recording paper; particular attention is also paid to keeping the hitches close together so as not to affect the normal hitch arrangements between load and tractor. The spiral spring in the form of the standard spring balance has also been employed as an indicating dynamometer to measure draw-bar pulls.

It will be well to set out the merits and demerits of the spring type of dynamometer before proceeding to a description of the other types.

The spring arrangement is a very simple one and enables the dynamometer to be self-contained. It can be made small in bulk, so that the normal hitching arrangements are not seriously altered by its introduction. Damping is very small and, indeed, may be considered negligible, with the result that any attempt at direct reading is very difficult owing to the extremely rapid fluctuations of the pointer throughout the test run when the dynamometer is being used under agricultural conditions. A record made with such a dynamometer, therefore, consists of a series of very fine serrations of large amplitude and an accurate evaluation of it either by integrating mechanism or by a planimeter is not possible.

There is a further disadvantage of the spring type, which is due to the elastic properties of the material. In order to obtain a deflection of the spring which will be large enough to enable an accurate reading or record to be made, it is necessary to arrange that the deflection for the maximum pull expected shall approach near to the elastic limit of the spring. In tractor testing experiments, however, there are very frequently encountered "snatches" or sudden very high pulls, as, for example, at the commencement of a run under heavy load, and these quite frequently rise to far above the range of pulls experienced during normal running and consequently overstrain the spring and so alter its calibration. The various ranges of draw-bar pull or draught necessitate different strength springs, and this type of dynamometer must be arranged to allow for a ready interchange of springs.

(2) HYDRAULIC TYPE DYNAMOMETERS.

While the spring type of apparatus remains in favour for certain kinds of measurements where the pulls are not subject to any serious sudden fluctuations, *e.g.*, in railway and river transport, measurements on roads and on the land are largely carried out with hydraulic apparatus. This type offers two advantages: damping out of the momentary fluctuations in the pull by the inelasticity of the fluid medium employed, and the possibility of placing the indicating and recording mechanism at some convenient distance away from the draw-bar.

The hydraulic dynamometer consists of a container, usually filled with oil of suitable viscosity to suit atmospheric conditions, and fitted with a plunger. The plunger and container are coupled respectively to the draw-bar of the prime mover and the implement so that the pull is transmitted from one to the other through the fluid. The pull is thus converted to fluid pressure directly proportional to the pull, and this pressure is conveyed through a pipe line to any convenient point for measurement and recording, thus avoiding the necessity for taking readings at the awkward position of a tractor draw-bar.

The actual measurement and recording of pull is thus reduced to that of measuring and recording pressure and hydraulic dynamometers differ mainly in the methods employed to measure this pressure.

British Association Dynamometer.—The earliest record of a dynamometer of this type being designed and used in this country is that made for the British Association Commission on the Resistance of Road Vehicles to Motion in 1902,[6] and used for research on the rolling resistances of a number of types of road wheel.

The frame carrying the wheel was pulled through a system of levers which transmitted the pull to a plunger in a cylinder full of water. The pressure set up in the water was measured and recorded by a Schaffer and Budenburg gauge employing a Bourdon tube. The maximum pressure reached in the tests was 100 lb. per square inch. The cylinder and tube were filled by pushing the wheel carriage up to that carrying the recording mechanism and forcing water in from a rubber bag through a tap which was closed when the dynamometer was full. Speed was measured by a recording tachometer driven from the land wheels of the vehicle carrying the recorder. Records were made on a roll of paper driven also from the land wheels, so that 10·3ft. corresponded to 1 mile of road. Calibration was by means of deadweight over a pulley, the instrument being tapped while the paper moved past the recording pen to obviate sticking.

Polikeit's Steam Plough Dynamometer.—An instrument very similar in type to this is produced commercially by P. Polikeit, and employs a scissors arrangement of bent levers to convert the draw-bar pull to pressure on liquid contained in a cylinder, and connected with a registering manometer of the Bourdon tube type. Different ranges of pull can be measured by coupling the levers together at different points, and so altering their arms. This instrument is capable of recording pulls up to 22,000 lb. on a paper strip driven from a land wheel. It is primarily designed for work on steam ploughs. A similar instrument, using a scissors linkage at the draw-bar with a piston and cylinder full of oil between the arms of the scissors and employing a Bristol recorder to measure the pressure set up, has been used in Michigan.[7]

Hyatt Dynamometer.—The Hyatt dynamometer, used largely in America and also in the 1919 Lincoln Tractor Trials, has been specially designed for farm measurements, and consists of a small plunger working in a bronze cylinder which is placed in the hitch of the implement. The cylinder contains a rubber bag, full of liquid against which the plunger presses, and the pressure so set up in the fluid is conveyed by flexible metallic tube to the Bourdon tube actuating the recording pen mechanism. The use of the rubber bag avoids the necessity of making the plunger a good fit in its cylinder, and so cheapens the cost of production, but at the same time must seriously affect the accuracy of the instrument by the rigidity of the rubber envelope. A needle valve is introduced into the pipe line to control the flow of liquid, and so damp out excessive vibration of the pen. As is usual, the chart is driven by a land wheel, and time intervals are recorded by a clock carried in the recorder case by an observer.

N.P.L. Dynamometer.—For further trials of tractors in 1920 conducted by the R.A.S.E., a dynamometer devised by the N.P.L. was used. This consisted of a pressure unit in which the plunger was in direct contact with the oil, only 0·001in. clearance was allowed between piston and cylinder, and a small cup leather helped to make the system oil-tight. To avoid the use of glands the draw-bar pull was converted into a thrust on an auxiliary plunger which was loosely connected to the main plunger to allow the latter to move freely in its cylinder.

The recording mechanism was again a Schaffer and Budenberg pressure recorder to which a second Bourdon tube had been added. A drive for the paper roll was taken from the land wheel of the instrument carriage through gearing, and allowed for the movement of the paper at the rate of 1in. to 10ft., 50ft., or 100ft. of ground travel. An arrangement of valves allowed either of the Bourdon tubes to be employed in a measurement, and so gave two ranges of measurement, 0–4000 lb., and 0–7000 lb. By a link mechanism the movement of the tubes at maximum load was magnified up to 4in. at the recording pen. The clock makes electrical contact at predetermined intervals of time, and momentarily displaces a pen recording on the paper—to facilitate counting, every fourth contact is missed. A third pen was fitted to indicate revolutions of engine or tractor wheels.

The dynamometer is primed by a small oil pump, and it was found that using fairly viscous cylinder oil in the pressure circuit gave sufficient damping.

The instrument was calibrated by deadweight—a bell trembler mechanism being used to obviate any possible stickiness in the pen motion and a sensitivity of 10 lb. on 2000 lb. is claimed, while it is stated that friction is negligible. It is emphasised that the apparatus is purely experimental, and presumably on these grounds claims immunity from criticism.

Watson Dynamometer.—A development along commercial lines from the N.P.L. dynamometer was that of[8] G. W. Watson, specially devised for the Shrewsbury Tractor Trials of the S.M.M.T. in 1920, and used also in some of the tests at the World Agricultural Tractor Trials[9] held in 1930.

This instrument was an ingenious attempt to make a compact and sturdy instrument which would measure and record all the variables necessary to the test of a tractor or implement, but the attempt resulted in an unwieldy and unnecessarily complicated device. The instrument consisted of a draw-bar unit which was directly coupled between the tractor and implement, an apparatus for measuring furrow depth in ploughing tests and a clock.

The drawbar unit consisted of a main hydraulic cylinder bolted to heavy end plates, to which the lever bars for the hitches were attached. One of the bars was integral with an end plate and the other, pivoted to the second end plate, presses through a steel ball on to the stem of a piston moving in the main hydraulic cylinder. The hitches to the tractor and its load are attached to these two lever bars respectively, and hence the drawbar pull of the tractor is converted into oil pressure in the main cylinder. A series of holes in the lever bars allows the position of the hitches to be varied, and hence provides a means of obtaining the same range of pressure variation for different ranges of drawbar pull. The pressure set up in the main cylinder is transmitted by a pipe to the measuring cylinder where it drives out a small plunger against a calibrated spring. The maximum movement of this plunger is $\frac{3}{8}$in., and is magnified up by linkwork to give an approximately linear movement of the pen of 3in. Stops are provided on the small plunger to prevent the linkwork from being strained in the event of an overload.

"Metallic" or carbon paper may be used for making the record and the main hydraulic cylinder serves as a marking roller. If carbon paper is used, the record is made on the underside of the chart—two additional rollers being needed to carry the carbon paper. As is the general practice, the paper is driven from a land wheel through a flexible drive and gearing at the rate of $1\frac{3}{8}$in. to 100ft. of ground travel. A friction drive to the receiving rollers allows for the variation in their diameter as the paper is wound on them. There are two other stylus points, one marks intervals of half a minute and the other traces a record of the depth of furrow as it is drawn. This latter is actuated by a cable from a bell crank lever carrying a castor wheel, running on the unploughed ground, and the land wheel in the furrow.

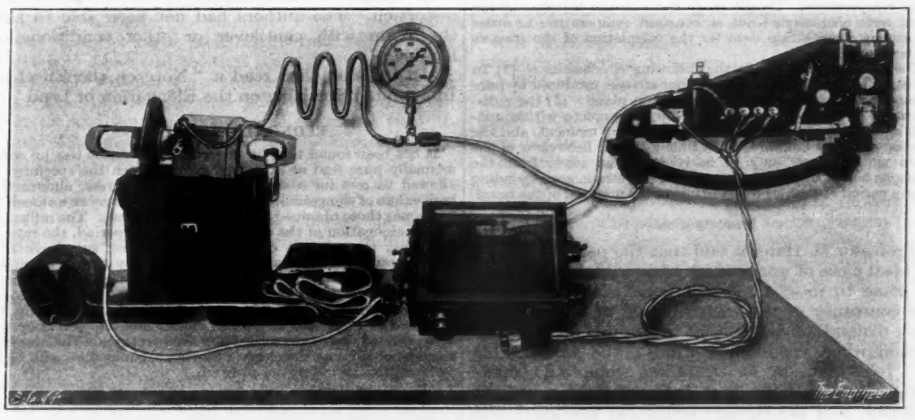


FIG. 2—ROTHAMSTED DYNAMOMETER

The dynamometer weighs some 60 lb., part of this being carried by the two wheels and part on the drawbar of the tractor. It is calibrated by deadweight and must be calibrated for both increasing and decreasing load, which implies marked friction in the cylinder and backlash in the lever movement. An integrating device was also arranged, but this will be described in the separate section on auxiliary apparatus.

Amsler Dynamometer.—Another commercially produced dynamometer similar in principle to the Watson instrument, but vastly superior in construction, is that of Amsler. Here again an oil-filled cylinder is employed, but the oil is contained in the space behind the piston, so that the pull is taken directly by the oil. No glands or cup leathers are used, the plunger and its stem being made a ground fit in the cylinder and its end plate respectively; so accurate is the work that oil leakage is very small and does not seriously affect working. The pressure set up in this pressure unit is measured by a small plunger about $\frac{1}{2}$in. diameter—a lapped fit in a cylinder and moving against a tension spring. The movement of the plunger actuates the pointer and pen mechanism and a record of the pull is made on a paper strip driven by a land wheel.

Rothamsted Dynamometer (*Fig.* 2).—A similar pressure unit to that of Amsler has been incorporated in the dynamometer developed at Rothamsted by Haines and Keen and made by the Cambridge Instrument Company. This instrument is in three parts, namely, the pressure unit similar to that described above, Bourdon tubes of large dimensions, and a Collins stress recorder. The pressure set up in the link is conveyed to the Bourdon tube, which has its ends fastened by means of special knife edge washers to the fixed and movable points of the stress recorder. The changes in length of the

[6] B.A. Report, 1903.

[7] *Agric. Eng'g.*, June, 1927, p. 145, E. C. Sauve.

[8] *Engineering*, June 30th, 1922.

[9] World Agricultural Tractor Trials, 1930, Official Report.

Bourdon tube are recorded on a strip of celluloid in the stress recorder by a special stylus which produces a deformation of the surface of the strip. The latter is driven past the stylus by a clockwork motor built into the recorder. A fixed stylus marks a reference line on the strip, and two electro-magnetically operated pens can be made to mark respectively time intervals and record by a code any special features of the test run. The record is not visible until some time after it has been made, even when the clockwork is running at its highest speed, and this is a serious disadvantage. Further, the record is small (it has a maximum displacement of about $\frac{1}{3}$in.), and is practically invisible to the naked eye. A special projection lantern is therefore used to form an image on a screen, where it may be examined and measured. The record is claimed to be permanent, but handling the film rapidly covers it with scratches similar in intensity to those composing the record. These mask it, and can often be confused with those of the zero and time-recording styles.

The recorder and the necessary batteries are carried by an operator walking beside the implement under test. Gear oil is used in the link and pressure circuit, and friction and damping are therefore high. Various ranges of measurement are provided for by different strengths of Bourdon tube, and an adjustment on the stress recorder allows for small differences in the unstretched lengths of these tubes.

(To be continued.)

Institute of Metals.

No. IV.

(Concluded from page 331, September 27th.)

THE next paper, presented by H. J. Tapsell and A. E. Johnson, reported "An Investigation of the Nature of Creep Under Stresses Produced by Pure Flexure."

CREEP UNDER PURE FLEXURE.

The paper deals with the results obtained in a study of the stresses and strains arising when a material is subjected to bending moments in conditions which produce creep. For experimental reasons it was necessary to use a material which would creep at air temperature, and for this reason lead of commercial purity was chosen. Apparatus was constructed by which a beam of lead was subjected to uniform bending moment and measurements of the creep of the beam were recorded. The whole equipment was housed in a chamber maintained at constant temperature. Tensile creep tests on the material of the beam were also carried out at constant temperature in order to provide stress-strain data for the calculation of the stresses in the beam.

The investigation led to the following conclusions :—(1) In the case of a lead beam creeping under stresses produced by pure flexure plane sections continue to remain plane ; (2) the redistribution of stress arising from creep is complete within one-fifth of an hour after application of a bending moment, and the stresses continue unaltered with time ; (3) the behaviour of the beam under flexure may be fairly computed solely from the relations between tensile stress and rate of strain, corresponding to any period of tensile creep testing on the material of the beam.

Discussion.

Professor D. Hanson said that the paper described an ideal piece of work, which had enabled the authors to come to most important conclusions. One was the constancy of the redistribution of stress (it had been realised, of course, that there must be a redistribution when yielding occurred) ; the second, that the redistribution of stress was complete within one-fifth of an hour after application of a bending moment, and the stresses continued unaltered with time ; and the third, which was the most important of all, was that the behaviour of a beam under flexure could be computed from the determination of creep in the ordinary tensile test. The estimation of the behaviour of materials under creep in bending was experimentally difficult, and if it proved experimentally correct, the authors would have done great service.

Mr. J. C. Chaston said it was difficult to understand why annealing at 100 deg. Cent. for two hours should have made the lead too soft, and he asked if the authors could indicate the change of hardness or of tensile strength. Generally speaking, he said, one did not expect a temperature of 100 deg. Cent. to produce such a great variation of strength ; it would have been far more satisfactory to have annealed at 100 deg. Cent. before carrying out the test, if that could have been done.

Mr. H. Stevens (Leeds) observed that both authors were engineers and had tried to bridge the very wide gap between engineering and metallurgy. The average engineer did not know the first thing about metallurgy, and the paper was very welcome. The authors had established a very fundamental point by showing definitely that under constant bending moment plane sections did remain plane. It would be expected theoretically, but it might be shown mathematically that under conditions of creep a plane section did not necessarily remain plane. They had established the ordinary theory of bending under constant bending moment. But he would like to see the work extended to include varying bending moment and varying rates of creep, and also to cover a beam subjected to non-uniform bending moments.

The President suggested that the reason why the discussion of the paper was short was that it described an altogether admirable piece of work, and the authors had proved their conclusions. Creep was important mainly, of course, at high temperatures so far as steel and other materials were concerned, and the authors had suggested in the first paragraph of the paper that they had in mind really the extent to which the conclusions they had drawn might be applied to steel and other materials, although they were guarded in their conclusions and limited them to the particular pieces of lead with which they had worked.

Mr. Tapsell, replying, said that the President had made the point which he also wanted to emphasise, that one must not assume that all metals would behave in the same way as the lead beam under experiment ; the conclusions arrived at as the result of the work on a lead beam must not be accepted as generalisations. But it was possible that the behaviour of simple metals would be the same as that of lead. In reply to Mr. Chaston, he could not explain why the lead was too soft after two hours treatment at 100 deg. Cent., but some quick tests were made and it was found that the creep rate was very much faster after annealing, and it would have been difficult to transport the beam without causing distortion. The authors had not been able to test the beam with cantilever or other conditions of loading.

Mr. Chaston then read a "Note on the Effect of Interrupted Straining on the Elongation of Lead."

ELONGATION OF LEAD.

It has been found that by interrupting a tensile test on commercially pure lead at intervals, during which the specimen is allowed to rest for a short time free from stress, abnormally high values of elongation are produced. These may be as much as five times those obtained in a normal tensile test. The influence on the elongation of the duration of the rest period, the rate of straining, the amount of elongation between successive rest periods, and the grain size have been studied by tests on extruded cable sheath samples. Abnormal elongations are not produced by interrupted straining on "hardened" lead alloys at room temperature, but it is suggested that such effects may be obtained in these and any other metals and alloys if they are tested above their recrystallisation temperatures. The observations recorded may thus have a bearing in connection with high-temperature metallurgical research.

Discussion.

Dr. C. J. Smithells said that the author's very pretty experiments and cautious summary tempted the less angelic to step in with some explanation of his results. The theory as to the slip on the grain boundaries did not appeal to Dr. Smithells as one which provided the proper explanation of the extension of the lead bars. He believed the explanation was to be found in the fact that stretching or drawing or rolling produced a uniformity in the orientation of the crystals, and recrystallisation did not destroy that. It had been shown in a great many cases—silver and copper, for example ; and it had been found also that tungsten, on complete recrystallisation at temperatures well above recrystallisation temperature, had a very strong preferred orientation. The majority of the crystals had the same orientation as those orientated by the cold work, and the result was that the bar had many of the properties of the single crystal. There was an artificial single crystal built up of a large number of grains orientated largely in the same relation to each other. That fitted in with the fact that the alloys having recrystallisation temperatures above room temperature did not behave in that way, for they were not allowed to rest at their recrystallisation temperatures.

At first he had thought that the work would be very interesting in connection with high-temperature materials, but usually, when the strain was taken off, the temperature was taken off as well—as in heating elements, lamp filaments, and turbine blades. They did not rest under temperature conditions, but at the lower temperatures at which recover occurred.

Mr. A. J. Murphy could not understand why the author had been surprised by his results ; surely they were such as would be expected. It seemed that the paper by Norbury to the Faraday Society in 1923 on "The Hardness and Spontaneous Annealing of Lead" would lead one to expect the results, the point being that lead was unusual among metals in that its recrystallisation temperature was close to ordinary temperatures ; further, Norbury and others had observed that the application of cold work could reduce the recrystallisation temperature to below room temperature. Arising from that, it would be useful if the author could indicate the temperature at which the stretching was carried out and at which the specimens were rested. It appeared that the large elongations obtained with interrupted straining were exactly analogous to the process of hot rolling copper alloys, for example. If one cold rolled a copper bar 12in. long and 2in. diameter, there was a limited extension before severe hardening occurred ; but if it were annealed at above recrystallisation temperature one could continue to elongate it until miles of 16-gauge wire were produced.

Any abnormality in the author's results seemed to arise purely from the fact that the specimen lost its cylindrical form. That was not unusual in a material having a coarse grain size in comparison with the dimensions of the test piece. If some measures had been taken during the cold working to restore the cylindrical form, as by rolling instead of applying a simple tensile stretch, he believed the behaviour of the lead would have been even more closely analogous to that of other materials, bearing in mind recrystallisation temperatures.

Professor D. Hanson said the author's results were similar in many ways to those obtained in testing the tin alloys, with which they might be fairly compared. Some tin alloys, when tested under prolonged loading, extended in a very remarkable way ; tin-bismuth alloys extended under creep conditions to a much greater extent than under normal conditions of testing. On the other hand, certain alloys showed the reverse effect. Cadmium-tin alloys could be made to break under prolonged loading before they had extended very far. In those tests the process of strain was not interrupted ; but the room temperature was acting. In the case of the tin alloys it was clear that those which extended a great deal annealed themselves continuously at room temperatures, and those which broke at very small extensions at room temperatures were not capable of annealing themselves at room temperatures. So that he was inclined to agree with Mr. Murphy that the results in the paper could be explained as being due to self-annealing at times of rest.

Dr. C. H. M. Jenkins said he gathered that the author, when speaking of recrystallisation, meant the formation of new grains by recrystallisation. He referred to some work of Professor Carpenter and Miss Elam in connection with grain growth of aluminium when deformed, and suggested that Mr. Chaston's results could be explained by stating that by applying increments of slow strain, and resting in between, grain growth was set up, leading to further softness. He referred to some work on iron and steel at high temperatures, where slow rates of creep would give grain growth, and rapid rates of deformation would give new grains.

Mr. Chaston, replying, said that grain growth during the resting period was not visible through the microscope, and at the end of the test the grain size was about the same as at the beginning. He believed X-ray work would show sometimes, however, a tendency to rearrangement of the lattice before it was made visible through the microscope by complete recrystallisation. He had had in mind preferred orientation, as suggested by Dr. Smithells, but he was not sure how it occurred

The results obtained were such as he had expected, but he had considered it worth while making the tests. A tensile test could not be compared with rolling, for the material was supported during rolling. By straining the material as he had done, one avoided the local constriction which occurred in the ordinary tensile test.

If it were true that great extension was due to continued annealing at room temperatures, one would expect lead, which annealed at room temperatures, to give long elongations under creep stress ; but the elongation under creep stress was usually shorter than under direct continual tensile testing.

Mr. Murphy suggested that there was a temporary hardening.

Corrosion of Magnesium.

A paper entitled "Corrosion Below Discontinuous Oxide Coatings, with Special Reference to Magnesium," by Mr. K. G. Lewis and Mr. U. R. Evans, was then presented. In it the authors describe tests made with magnesium, uncoated and coated with oxide layers produced by three different treatments applied for numerous different periods, and subjected to sodium chloride in a new circulating apparatus.

Mr. H. Sutton, opening the discussion, extended to the authors a cordial welcome to the small band of searchers after truth who had given attention to the difficult problem dealt with in the paper. They had shown that chromate films permitted severe local attack under immersion conditions of a severe nature. Magnesium seemed very willing indeed to behave as anode, and it seemed difficult to believe that stifling of the cathodic reaction alone would do substantially more than affect the distribution of corrosion. Uniformly distributed corrosion was generally much less objectionable than the more local form often experienced with light metals and alloys, and the new line of approach put forward by the authors was likely to be valuable if it could be combined with a surface treatment giving a high degree of protection.

It was interesting that the authors had worked on high-purity magnesium and not on alloys. There would seem to be greater tendency for anodic and cathodic areas to form in abundance in alloys than in the pure metal, and for that reason the value of a

cathodic inhibitor might be much greater in the case of the alloys. He did not wish to suggest that the authors should have used alloys, but merely mentioned the possibility of very useful results from the application of their method to alloys rich in magnesium.

He asked the authors how they knew when perforation was completed. In some recent work on some experimental magnesium alloy tanks, it was found, when exposing one side of sheet material only to corroding agents, that actual perforation occurred much earlier than would be supposed from visual observations on the corroding surface, and sometimes took the form of the development of sponginess with porosity over a considerable area, which would not have been observed so soon but for liquid seeping through.

The fact that the authors had not observed perforation in any of their specimens exposed to salt spray for three months was of interest, in view of the relatively rapid perforation experienced in the immersion tests. It might be worth while to determine the metal lost by corrosion in the salt spray tests when they had proceeded for an appropriate time, in order to see how the protective treatment affected the total loss by corrosion.

Commenting on the Dr. Evans' proposed method of stifling the cathodic reaction, he said that zinc chromate had proved of the greatest value and superior to other chromates as a pigment for magnesium alloy samples exposed to sea water spray.

Dr. L. C. Bannister, who pointed out that in nearly all laboratory corrosion tests in glass vessels there was a certain amount of movement or stirring of the liquid, sometimes unrecognised, although it could exert a very definite control on the corrosion rate, said the authors had most ingeniously brought about a type of stirring in the form of a circulation of the liquid, which probably predominated over the movements brought about by thermal and other effects. He believed that was the first time the products of corrosion had deliberately been utilised for stirring the corroding medium. Some years ago he had devised a simple apparatus for circulating the corroding medium by means of an air-lift or a supply of some inert gas, and other workers had used it very successfully since. The apparatus used by the authors, however, was even more simple, but it produced a slightly different effect, because the flow of corroding medium, being controlled by evolution of gas, was not the same for all the test pieces, and it was not constant throughout the experiment for any one test piece. That explained, he believed, why some of the authors' curves were slightly convex to the time axis when the initial gas evolution was slow. The authors had not commented on the two types of curves, but had merely stated, quite correctly, that the liquid above the metal was replaced at a rate roughly proportional to the degree of exhaustion. The concave curves (shown particularly by the uncoated specimens) would probably have been more nearly straight lines if a larger volume of corroding medium had been used. Although the liquid was renewed at the metal surface, it must be remembered that it was renewed in a somewhat impoverished condition.

Apart from that, the experimental conditions seemed to have been chosen with very great care. The abrasion treatment generally employed by corrosion workers to obtain a clean metal surface was difficult to standardise, but the adoption of the procedure used for preparing metallographic specimens was an improvement which he had been using also for some little time. There were many points in the paper which would be extremely useful to those who were still struggling in industry with that difficult subject, for, in the words used recently by the President, in spite of the limitations of laboratory tests, they must continue to be the preliminary basis for the comparison and selection of materials.

Dr. L. Whitby said he was glad the authors had called attention to the fact that in practice magnesium alloys were used. Dr. Bengough and himself felt that until service tests had been carried out on alloys with the addition of top coats of paints, the interesting method evolved by the authors for protecting magnesium must remain of academic interest only.

In the spray tests the authors had included specimens treated by the selenium process, but, unfortunately, they had used a selenium bath which was unsuitable for pure magnesium, and undoubtedly gave results which were not normal. Although Dr. Bengough and he had never worked on the protection of pure magnesium, they had evolved a selenium bath for the 98 per cent. Elektron magnesium alloy AM 503. The bath contained 2 per cent. of Na_2SeO_3 and 2 per cent. by volume of phosphoric acid, and was more suitable for use with magnesium than were selenious acid baths, which latter were used only for alloys containing aluminium. They had repeated some of the authors' work with pure magnesium, using, however, instead of a selenious bath, the Na_2SeO_3 bath, and, in addition, had tested the method with the Elektron alloys ALM and AM 503. In each case the specimens, in the form of sheets, were dipped in the zinc sulphate, ammonium nitrate bath for two minutes. For the selenium treatment, which, together with blanks, was used for comparison, the standard 10 per cent. SeO_2 bath was used for the ALM alloy and the Na_2SeO_3 phosphoric acid bath for the magnesium and the AM 503 alloy. The specimens of the alloys were exposed in triplicate, and those of the magnesium in duplicate, and were sprayed three times daily with sea water for three weeks and two weeks respectively. After exposure, the losses of weights were determined. In the case of the ALM alloy the zinc hydroxide method gave no apparent protection. The protection in the cases of the AM 503 and the pure magnesium was appreciable, but the selenium-treated magnesium suffered practically no corrosion.

Dr. Whitby emphasised that when using selenium it was essential to use the appropriate bath for the alloy concerned.

Dr. H. W. Brownsdon said that the authors' method of testing for perforation was applied daily to zinc, a similar type of metal, and it was surprising how far the time of perforation was improved by annealing the material. The authors had dealt with a hard-rolled magnesium. If it had been annealed suitably, he believed all the curves would have been changed favourably, showing that the perforation occurred much later in the annealed metal.

Dr. Evans, replying, agreed with most of Mr. Sutton's comments. In the early stages of the work, he said, the authors had been deceived sometimes, and had had doubts as to whether a specimen had become perforated; but later the specimens were held up to powerful light, and he did not think there was any doubt then as to whether or not perforation had occurred. One could miss a perforation by reason of its being filled with a very bulky corrosion product, but he did not think there was any doubt about it in the sort of specimens the authors had used, although when experimenting with tanks there might be difficulty.

It must be left for further work to decide whether the zinc oxide process would be usefully combined with other coats on top. Some work was being done with iron, some outdoor tests having been carried on for some months already.

He agreed with Dr. Bannister that it would have been better to have used larger volumes of liquid; the authors had realised that towards the end of their work. He was not quite sure that the volume of the corroding liquid used was the only reason for the convex and concave curves. He fancied that the concave curves were due to the breakdown starting at certain points and spreading out. There were certain advantages and disadvantages in having the circulation controlled by the corrosion reactions, and it was not for him to decide whether the advantages or disadvantages predominated. It might be best to experiment with both systems simultaneously.

He regretted that he had not used the selenium bath, which was most useful for magnesium, and agreed that one should use the bath appropriate for the alloy concerned. That also applied to the zinc sulphate, ammonium nitrate bath. Different proportions were required when treating iron than when treating magnesium.

It was quite possible that annealing of the specimens might have produced results more favourable from the industrial point of view, and less favourable from the point of view of the experimentalist, who wanted to obtain results quickly. However, the results might have been the other way round.

"The Protection of Magnesium Alloys Against Corrosion," was the title of a paper by Mr. H. Sutton and Mr. L. F. LeBrocq, which is summarised below:

MAGNESIUM ALLOYS AND CORROSION.

Short-time chromate treatments of magnesium-rich alloys of two types in common use have been investigated, and the protective value of the treatments has been compared with the six-hour chromate treatment and other forms of protective treatment.

A bath has been evolved capable of giving good films in thirty to forty-five minutes and is suitable for use in steel or aluminium tanks.

The protective value of the six-hour and short-time chromate treatments, with and without supplementary coatings of varnishes and enamels, has been investigated with reference to typical alloys. Intermittent sea water spray laboratory tests and beach exposure tests were carried out, and the corrosion which occurred was observed by loss of weight and change in mechanical properties.

Experiments were carried out on the influence of cleaning treatments employed before chromate treatment.

DISCUSSION.

Mr. W. M. Corse (corresponding member in the U.S.A.), in a written contribution, stated that the corrosion of magnesium and its alloys by sea water had been described to him by Mr. Sutton as "audible" corrosion—a very descriptive term. However, when one considered the success achieved in similar problems on iron and steel, both of which materials were corroded badly under salt water conditions, there was some hope about a material such as magnesium, which had such splendid properties and was so useful from the point of view of light weight, being protected in a practical way, so that its use under certain sea-water conditions might be possible. He had seen enough of the results in Mr. Sutton's laboratory to make him feel very optimistic about ultimate success. Workers in the United States were making every effort to co-operate in the solution of the problem, for anything which helped to further the use of magnesium, no matter where evolved, would be a distinct step in advance.

The President emphasised the rapidly increasing importance of magnesium as a structural material. Recent figures, he said, indicated that the production of magnesium in America was bounding up, and one would like to see a largely increased production in other parts of the world also.

Dr. U. R. Evans, having acknowledged that the paper contained a vast amount of extremely valuable information which would be accepted as fact, used for reference, and put into practice, said that the use of strontium chromate in the protective coverings seemed rather new. Why use chromate alone, and why strontium chromate more than any other chromate? In more or less neutral solutions, chromates became reduced superficially to mixtures containing Cr_2O_3, which had very good protective properties. At the same time, in acid solutions chromates were reduced to soluble chromic salts, so that in those circumstances chromates might actually stimulate corrosion. In a reference to some experiments on steel covered with paint containing chromates at Cambridge, he said that in summer, when the rain was more or less neutral, the results were good, whereas in winter, when the rain became acid, the paint behaved much worse than most of the other paints tested. He was not sure that if the authors' experiments had been carried out among the chimneys of Widnes or Sheffield, instead of among the sand castles of Felixstowe, the protective coverings would have given such good results.

Discussing the question as to why strontium chromate was used more than any other, he said the chromates could be arranged in order of their solubility, lead and barium chromates being at one end and potassium chromate at the other. The very soluble ones, such as the potassium chromate, would protect extremely well because they gave a concentrated solution in the mixture so long as the chromate remained; but it would not remain very long. On the other hand, when using the relatively insoluble ones, such as lead chromate, the chromate would remain for a very long time, but it was quite on the cards that the concentration of chromate in the mixture covering the metallic specimen might be insufficient to stifle corrosion at the most susceptible points. Whilst he fully accepted that chromates were good in Mr. Sutton's hands, they were very fickle friends, and needed to be very carefully tested, as Mr. Sutton had tested them. One could trust them just about as far as one could see them. He had experienced many cases where, under certain conditions, the chromates would make matters very much better, whereas under slightly different conditions they would make matters very much worse. There was evidence of their fickleness, even in the paper.

Dr. L. Whitby said the authors had produced so large a quantity of useful results that he felt somewhat ungracious in stating that Dr. Bengough and himself would have liked to have seen the results of a greater number of strictly comparable experiments between chromate and selenium treatments.

The authors had stated that red pustules were formed after exposure to sea water on the enamelled surface of the specimens which had received selenium treatment, but they had admitted that the amount of corrosion of the underlying alloy was slight. Some years ago the conclusion was arrived at that the red pustules formed mainly on excessively porous paints, and were a sign of the self-healing properties of selenium. Each of the red spots was thought to correspond with a pore in the paint film, and was found to have been formed by a transference of the selenium from the metal to the outside of the pore in the paint. Therefore, he submitted that their presence was an advantage rather than a disadvantage, since without selenium there would be, not innocent red pustules with no corrosion underneath, but more attractive-looking blisters æsthetically concealing corrosion.

By means of a slide, Dr. Whitby illustrated the formation of the pustules on a porous aluminium-pigmented bitumen-base paint, applied over a selenium-treated alloy. The paint had been removed, and each red spot on the paint film coincided with a pale patch on the selenium base, where the selenium had been transferred. Innumerable tests had been carried out also with practically every paint medium of practical importance, and there was no reason to change the view that selenium appeared on the outside of a paint only when that paint had broken down.

The self-healing property of selenium was demonstrated also by plotting the loss of weight against time of treated specimens when they were subjected to corrosion by sea water spray.

Mr. Sutton, replying to Dr. Evans, said that the authors had borne in mind the solubilities of chromates when selecting their pigments, and had thought that strontium chromate would probably strike a happy balance between having a reserve of chromate undissolved and a useful amount in solution. With barium sulphate the solubility seemed too high to give a happy balance.

Some of the bad results obtained were particularly marked in the case of stoving enamels, and he understood that some of those enamels were prone to develop acidity during the stoving. That might explain the poor results obtained in some of the tests.

No further papers were presented for discussion.

The Shipping, Engineering and Machinery Exhibition at Olympia.

No. IV.

(*Continued from page 318, September 27th.*)

C. C. Wakefield and Co., Ltd.

THE importance of adequate lubrication of wearing parts has, of course, always been realised by the engineer, but in practice the supply of lubricant was frequently neglected when it had to be carried out by a man with a grease gun and an oil can. In comparatively recent years, however, a change has come about, and, for many kinds of machinery, devices are now available for lubricating automatically at regular intervals either with oil or grease those parts of machinery which had formerly to rely upon the somewhat irregular attentions of a human oiler. Among the firms making such devices is C. C. Wakefield and Co., Ltd., of 30–32, Cheapside, London, E.C.2, and in the line engravings Figs. 35 and 36 we illustrate a mechanical grease lubricator for rolling mills, colliery equipment, and cement and papermaking machinery, &c., and an automatic chain conveyor lubricator respectively, both of which were exhibited at Olympia. The first-named is much like others of its type, the working parts being contained in a circular "pump chamber" surmounted by a more lightly constructed grease container. On the outside of the pump chamber are arranged a number of valve assemblies, from which grease supply pipes lead away to the various points on the machine which need lubrication. Adjustments are provided on these valves for altering the rate at which the grease is supplied through each individual pipe. The internal mechanism can be operated by either ratchet pulley or sprocket drive to the worm shaft A. A ratchet drive is suggested in the drawing. The rotation of the worm causes a shaft carrying excentrics to rotate about a central fixed spindle, and the excentrics, of course, force back the spring-loaded plungers of the individual pumps B B through the medium of the excentric rollers C. The upper end of the spindle carries a fixed blade, under which there travels a revolving scraper and scoop D, which forces the grease downwards into the pump chamber. The fixed blade prevents the rotary motion of the scraper being communicated to the grease in the container above. Provision is made in the design of the individual pumps to allow any air that may be present to escape at the end of the delivery stroke.

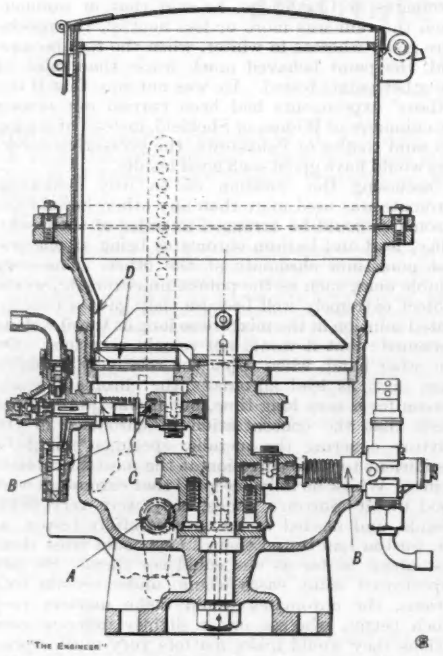


FIG. 35—MECHANICAL GREASE LUBRICATOR—WAKEFIELD

The design of the chain conveyor lubricator is easily followed from the drawing. The device is supported above the path of the conveyor wheels on brackets. It consists of a container for the oil, within which there is a pump. As each wheel of the conveyor passes beneath the device it lifts a roller and thereby causes the plunger of the pump to be forced upwards against the pressure of a return spring. This action causes oil to be forced down the centre of the hollow plunger through a spring-loaded ball valve to delivery pipes mounted in ball sockets which carry the oil to a point from which it will drop on to the bearings to be lubricated. It will be observed that, should the conveyor happen to stop in such a position that a wheel comes beneath the roller, the supply of lubricant will not continue to flow. The roller is mounted on an arm swinging about a fulcrum and adjustment for the amount of oil delivered at the passage of each wheel is provided by a screwed regulator, the end of which bears on an extension of the arm and thereby alters the distance through which the roller can be lifted. At the top of the pump barrel there is an air outlet cock.

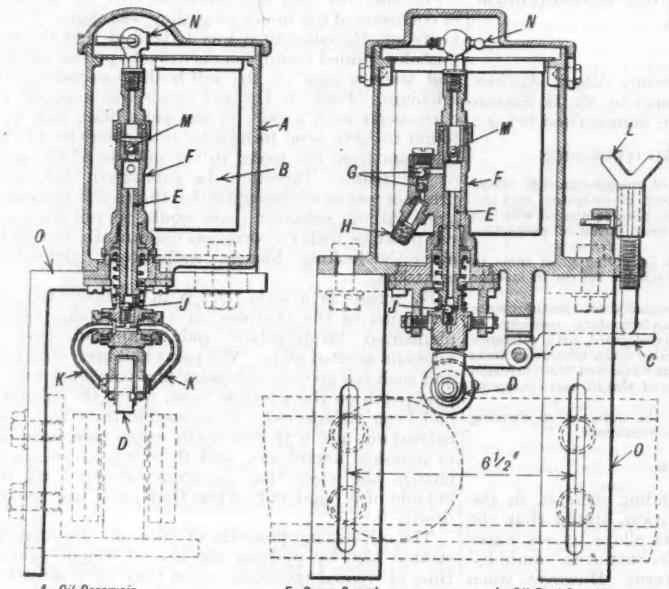


FIG. 36—CHAIN CONVEYOR LUBRICATOR—WAKEFIELD

Petters, Ltd.

From a wide selection of oil engines shown on the stand of Petters, Ltd., of Yeovil, and Bush House, London, we have chosen two models which were exhibited for the first time, and which are representative of the firm's latest developments in marine and land practice. The Petter "Atomic" engine was represented by the four-cylinder, 55 b.h.p. marine engine, complete with mechanical reverse gear, which we illustrate in Fig. 37 herewith. These engines have cylinders with a bore of 5¾in. and a stroke of 8½in., and operate on the two-stroke cycle, with airless injection. The crank case is of the monobloc type, with large inspection doors giving easy access to the working parts. Fig. 37 clearly shows the arrangement of the fuel pumps and automatic lubricators, also the neatly grouped engine controls at the reverse gear end of the unit. These engines are designed to use a wide range of oil fuels, and their performance at slow speeds and the manœuvring qualities are, we are informed, very satisfactory.

The engine shown on the stand was of the smaller power type, and had therefore a mechanical reverse gear. For the larger sizes of engines from 120 to 300 b.h.p., however, direct-air reversing with single-wheel control is fitted.

The land-type "Atomic" engines were represented by various units with designed outputs of 10, 20, and 50 b.h.p., while a further exhibit was a 2-kW fully automatic electric generating set which can be supplied as an emergency set for marine or land use.

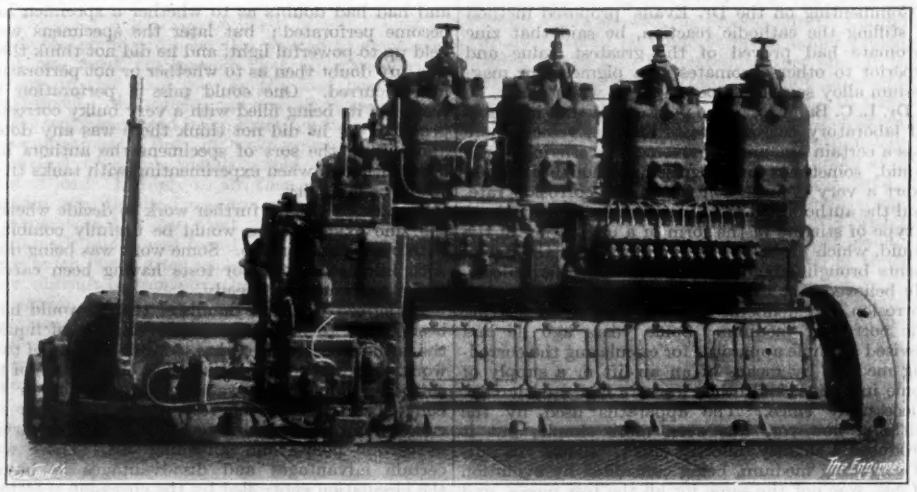


FIG. 37—55 B.H.P. "ATOMIC" ENGINE—PETTERS

An entirely new design of engine was represented by the 110 b.h.p. blower scavenge engine shown in Fig. 38, which is a twin-cylinder, 8¼in. bore and 13in. stroke unit of a series with cylinders from two to six in number and designed outputs of from 110 to 330 b.h.p. at 500 r.p.m. On the first two engines constructed a fuel consumption of the order of 0·39 lb. per b.h.p.-hour was obtained at full load, and the makers are confident that these performances will be improved upon later. The lubricating oil consumption works out at about 1 per cent. of the full-load fuel consumption. As our illustration indicates, a monobloc pattern of crank case has been chosen. Detachable liners having machined ports are fitted. The combustion chamber is of the open type, and there are three groups of scavenge ports. The scavenge operation proper is performed by two sets of ports on opposed sides of the liner, while a third group opposite the exhaust ports is valve-controlled, and is designed to fulfil the dual purpose of giving a slight supercharge and of superimposing a certain amount of swirl on the entering scavenge

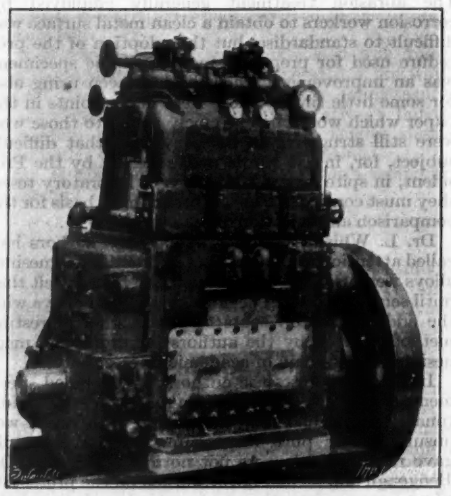


FIG. 38—110 B.H.P. BLOWER SCAVENGE ENGINE—PETTERS

air at a point in the cycle at which such action is not detrimental to efficient scavenging. The scavenge pump is of the Zoller positive type and is gear driven from the engine crankshaft. The air is delivered at 2½ lb. per square inch pressure. The controlled valves are operated by excentrics from the cam shaft. The fuel pump is of the Simms uniflow type, with a pump for each cylinder. The governor is of the crankshaft type and the tachometer is mounted on the end of the governor spindle. There is a neat fuel-metering device with a visible flow indicator attached to the end casing. A dry sump lubricating oil system is used with gear-type pressure pumps and an Auto-Klean strainer. The piston is of a new type incorporating a neat form of spherical small end bearing, and oil cooling is employed.

JOHN I. THORNYCROFT AND CO., LTD.

The smallest model in the range of paraffin engines exhibited by John I. Thornycroft and Co., Ltd., was the "Handybilly" model, designed for the smaller

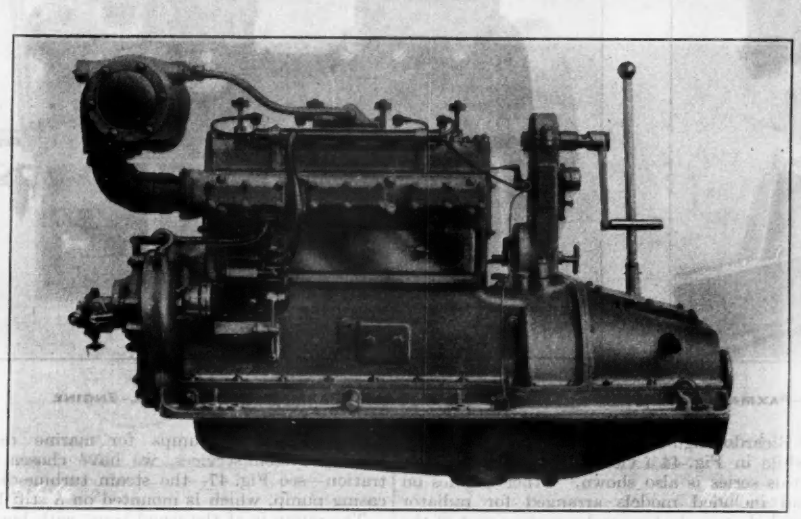


FIG. 39—36-50 B.H.P. PETROL-PARAFFIN ENGINE—THORNYCROFT

classes of launches, cabin cruisers, and ships' lifeboats, &c. The engine, which has a bore of 3½in. and a stroke of 4½in., has an output of 7½ b.h.p. at 1100 r.p.m., and embodied in it is the Thornycroft patented combined reducing reversing gear. It is also available as a petrol engine, in which case the power is 9 b.h.p. at 1100 r.p.m.

A further exhibit was the "Pilot" type engine, which is a comparative newcomer to the Thornycroft range. The normal power on paraffin is 13 b.h.p. at 1600 r.p.m., whilst that of the petrol engine is 14 b.h.p. at 1600 r.p.m. A high-power engine of similar design, also with 2 13/16in. bore and 4in. stroke, is also available and incorporates special features which allow it to be

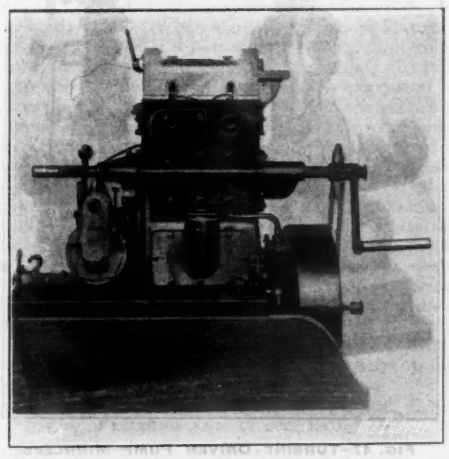


FIG. 40—18 B.H.P. TWIN-CYLINDER OIL ENGINE —THORNYCROFT

installed at a steep shaft angle. It is known as the "Pike" and is only supplied as a petrol set, designed to develop 26 b.h.p. at 3000 r.p.m.

A petrol engine whose rated power is 36 b.h.p., 4½in. bore, 5½in. stroke, and running at 1500 r.p.m., is the "Porpoise" type, illustrated in Fig. 39. It has been installed in Thames passenger launches, yachts, lifeboats, and commercial craft of every description. Engines of this type in powers of 30, 75, and 140 b.h.p. are manufactured.

Three heavy-oil engines were shown, the smallest being a single-cylinder engine of 9 b.h.p. at 1300 r.p.m. It is fitted with combined reducing reversing gear. Its performance and smooth running has, we understand, largely overcome the prejudice primarily shown against high-speed single-cylinder Diesel engines, and it has found uses in commercial craft as well as auxiliary yachts.

A similar engine with two cylinders, 4in. bore, and 6in. stroke, which develops 18 b.h.p. at 1200 r.p.m., is shown in Fig. 40. Although its introduction took place only a year ago, it has been chosen as the power unit for the lifeboats of the "Queen Mary."

The remaining exhibit was the largest of the oil engines with a cylinder bore of 4½in. and a stroke of 6½in., designed to develop 120 b.h.p. at 1600 r.p.m. As it is of comparatively high power, it is suitable for a large range of craft, and engines of this type have been installed in the twin-screw yachts "Varis" and "Poisson Sorcier," and the twin-screw Monte Carlo passenger boat "La Dryade," which conveys passengers from the large liners to the popular French resort. Four boats with these engines installed were used in connection with the laying of the recently completed Iraq pipe line. Another interesting installation is the triple-screw Chinese Customs patrol vessel "Hsiaan," which patrols the Upper Yangtse River. The engine exhibited was fitted with a reverse and reducing gear, which has been supplied to the Admiralty and R.A.F., in addition to engine manufacturers.

In addition to the marine engine exhibits there were shown examples of oil fuel gear, Thornycroft propeller work, and a range of models of various craft produced by this firm.

JOHN LILLEY AND SON, LTD.

The firm of John Lilley and Son, Ltd., of North Shields, was showing a large number of nautical instruments, such as trim indicators, draught gauges, chart holders, binnacles, and compasses, and the firm's stand was of particular interest to navigators. From these exhibits we have illustrated in Fig. 41 the "Unit"

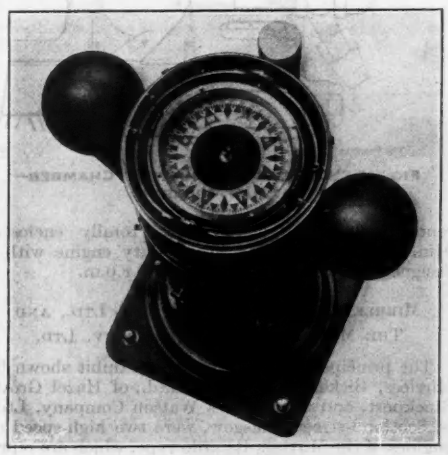


FIG. 41—"UNIT" COMPASS—LILLEY

compass, which has an ingenious suspension. Since the advent of the oil engine-driven ship makers of compasses have found it necessary to modify systems of suspension of the card owing, not perhaps so much to increased vibration, as to a difference in the periodicity as compared with steam-propelled vessels. The compass is of the dry card type and is shown with an improved type of helmet. Hitherto when compass bearings have been required the helmet has been lifted off and laid on the deck in order that the azimuth mirror might be placed on the compass glass. The firm has now produced a hemispherical top, which need not be removed, but is revolved under the compass bowl and returned again when the bearing has been taken.

THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

Among the numerous exhibits on the stand of the D.S.I.R., concerning which we have already made some general mention, there was one which in spite of the simplicity of the idea which it embodies fascinated the attention of many visitors. Although the device in question has been evolved to deal with a directly practical problem the mathematically minded reader may see in it an interesting illustration of the theory of probability.

The object sought is to divide a stream of air carrying powdered coal into two—or more—sub-streams which shall at all times and under all circumstances consist of equal quantities of air and fuel. The device is applicable, by way of example, to a powdered-fuel-fired boiler with two burners. If the supply pipe is simply branched, it is practically certain that one branch will receive more air or more fuel than the other. The air flow in the supply pipe cannot be assumed to be uniform across the section while the fuel which it carries is almost bound to exhibit a partial segregation of the heavier particles from the lighter. These factors militate against the attainment of an equal subdivision with the result in practice that the two burners operate under conditions of unequal load and unequal combustion efficiency.

The simple arrangement evolved to ensure equality in the two sub-streams consists of a chequer block which is inserted in the supply pipe just before it branches to the burners. This chequer block divides the stream into a number of filaments which are reunited, in a certain order, into two—or more—sub-streams. At A in Fig. 42 we illustrate the upper,

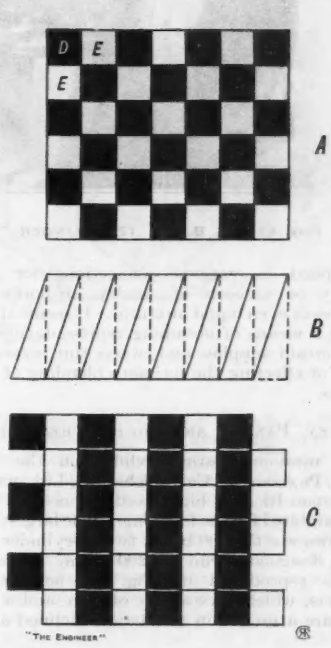


FIG. 42—FLOW DIVIDER—D.S.I.R.

or inlet, face of a chequer block designed to serve two burners. It presents a honeycomb appearance and consists, by way of example, of cells 1in. square arranged in six rows of seven each. For identification purposes we have indicated the cells in black and white. The second, fourth and sixth rows of cells pass straight through the block as indicated by the dotted lines at B. The first, third and fifth rows are inclined, as shown by the full lines, to such an extent that their exits on the lower face of the block are displaced 1in. to the left relatively to their inlets. The underside of the block therefore appears as shown at C. It will be seen that the draught-board arrangement of the inlet face is transformed on the outlet face to three lines of white and three lines of black cells with three isolated black cells on the left and three isolated white cells on the right. The flows out of the black cells are collected in four ducts which unite and feed one burner. The flows out of the white cells are similarly collected and united and feed the other burner.

The action of the device was convincingly demonstrated by means of a model into which a jarful of large white beads and small green beads was poured. The two streams into which the supply was divided were caught in separate beakers and each beakerful was subsequently passed over a separator which divided the white beads from the green. On subsequent comparison the two lots of green beads were seen to be visibly equal in number and the two lots of white beads also to be equal. We prefer this demonstration of the action to any mathematical explanation of it. If the reader loves a paradox let him consider this problem: Assume that X per cent. of the flow consists of heavy particles and that all the heavy particles flow through the corner cell marked D and all the light particles through the remaining forty-one cells. What value must X have in order that the flow of fuel may be the same to the two burners? If the heavy-particle flow spreads over the three corner cells, D E E, what new value does X assume?

To divide the supply into three sub-streams the chequer block is made in the form of nine rows of

nine cells each. The first row is inclined to the left, the second goes straight through and the third is inclined to the right. To divide the supply into four streams three chequer blocks of the type illustrated in Fig. 42 would be used to divide it twice into two parts.

In practice the chequer block is built up from welded steel plates. The manufacturing rights in the invention are in the hands of the Sheepbridge Coal and Iron Company, Ltd. The device would appear to have many possible applications outside the use for which it was originally designed. It might be applied in various connections for securing equality of division of sundry air-borne powder mixtures or even liquid mixtures. It seems applicable, too, as a means of obtaining representative samples from certain supplies and, when run reversed, as a means of effecting the intimate blending of multiple streams.

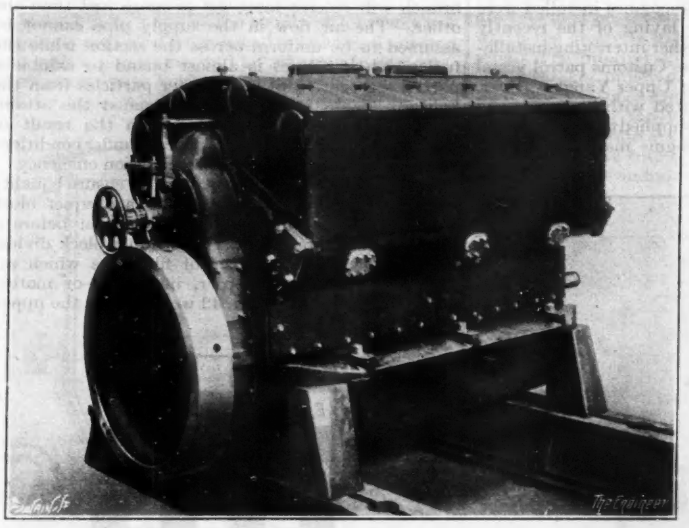


FIG. 43—500 B.H.P. 12-CYLINDER "V" OIL-ENGINE—PAXMAN

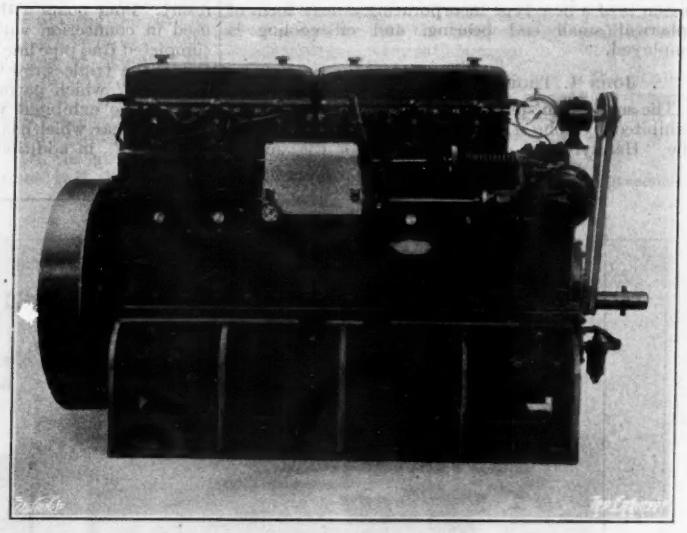


FIG. 45—60 B.H.P. PAXMAN-RICARDO OIL-ENGINE

Davey, Paxman and Co. (Colchester), Ltd.

The most interesting exhibit on the stand of Davey, Paxman and Co. (Colchester), Ltd., was a series of Paxman-Ricardo high-speed engines, all of which were exhibited for the first time. The largest engine in this series was the 500 b.h.p. twelve-cylinder Vee R.A. model, designed to run at 1200 r.p.m. A view of this unit is reproduced in Fig. 43 herewith. The cylinders, which have a bore of 6½in. and a stroke of 7½in., are arranged in two banks inclined at 60 deg.

FIG. 44—10 B.H.P. PAXMAN-RICARDO OIL-ENGINE

A forked connecting-rod and plain connecting-rod on opposing cylinders enable a six-throw crankshaft to be employed, which is carried in the bed-plate. The bed-plate is of cast iron with heavy side members, and there are also continuous keyways formed in the bed-plate and the cylinder block, which tie the whole structure together. The engine is fitted with independent cylinder heads, which contain all the valves and air starting gear, and with the Ricardo "Comet" and "Whirlpool" type combustion chamber. The general design of the "Comet" head is illustrated in Fig. 46. It may be noted that large inspection doors are provided along either side of the cylinder block, which, when removed, give full access to the large end bearings. It is a simple matter to uncouple these bearings and withdraw the pistons upwards.

A single cam shaft operates the overhead valves through short rockers and push rods. There are two six-cylinder Bosch fuel pumps, which are mounted in the trough of the vee and are placed above the cam shaft tunnel. Air starting is fitted, a two-stage Heywood air compressor being used, while the water circulating pump is of the Taynor patented construction. A feature of the new engine is the manner in which all manifolds are so arranged that connections may be made to either end. The engine has been designed to comply with Lloyd's highest requirements for marine propulsion service and was constructed under Lloyd's survey. The tests of this new unit, which has been designed for railcar and marine services, will be awaited with interest.

In Fig. 45 we illustrate a six-cylinder 60 b.h.p. Paxman-Ricardo engine of the 1000 r.p.m. "R.Q." type; while in Fig. 44 a view of the single-cylinder unit in this series is also shown. Other engines on the stand included models arranged for radiator cooling and electric starting and a marine unit of the Paxman-Acro type complete with a reversing propeller, which has a designed output of 7 b.h.p. at 1500 r.p.m. The medium-speed series of engines was

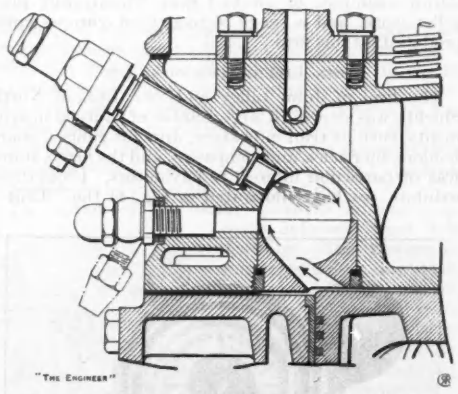


FIG. 46—"COMET" COMBUSTION CHAMBER—PAXMAN-RICARDO

represented by a five-cylinder, totally enclosed, 9½in. bore, 10in. stroke, heavy duty engine with a designed output of 250 b.h.p. at 600 r.p.m.

Mirrlees, Bickerton and Day, Ltd., and The Mirrlees Watson Company, Ltd.

The principal items in the joint exhibit shown by Mirrlees, Bickerton and Day, Ltd., of Hazel Grove, Stockport, and the Mirrlees Watson Company, Ltd., of Scotland-street, Glasgow, were two high-speed oil engines of the Mirrlees-Ricardo type, which are representative of two series with designed outputs of 20 b.h.p. and 50 b.h.p. per cylinder at 1200 and 900 r.p.m. respectively. Both series are constructed in units from two to eight cylinders and can be supplied to meet the individual preferences of the customer either as sleeve valve or poppet valve engines. Both the engines shown on the stand were six-cylinder models and embody the Ricardo "Comet" type combustion head. On page 350—Fig. 53—we illustrate the poppet valve type of engine, which has a designed normal output of 300 b.h.p. at 900 r.p.m. and a maximum output of 330 b.h.p. The engine follows the makers' standard practice and we noted that a built-up crankshaft is used. Welding is employed for light covers and manifolds and large light alloy inspection doors, which give easy access to the crankshaft and bearings are fitted. Attention may be drawn to the instrument table at the fly-wheel end of the engine, on which the tachometer and oil pressure gauge are flush mounted. The working parts are totally enclosed and are forced lubricated, including the valve rocker arms. The smaller engine exhibited has a designed output of 20 b.h.p. per cylinder at 1200 r.p.m. and can also be supplied as a sleeve valve or poppet valve engine. Another exhibit was an interesting range of scale models of engines illustrating the development of Mirrlees-Diesel engines from the first one, built in 1897, which was also the first Diesel engine made in Great Britain, to the latest type of completely enclosed, forced lubrication airless injection engine, embodying the experience of thirty-eight years of oil engine manufacture. A Mirrlees "Combustioneer" stoker with a 100 lb. an hour capacity was also on view.

From the Mirrlees Watson exhibits, which included various types of pumps for marine duties and heating system services, we have chosen for illustration—see Fig. 47—the steam turbine-driven split casing pump, which is mounted on a stiff bed-plate.

The pump is of the usual type, with both suction and delivery branches on the lower half casing, which enables it to be opened up and inspected without interference with any pipe joints. The pump shaft is protected by brass or nitrided steel sleeves. Rubbing rings are fitted in the pump casing with a special grooved fixing. The turbine is of the simple impulse radial flow type, arranged with velocity stages, so that three impingements take place. Carbon glands with non-corrodible springs are fitted and the shaft is protected by non-corrodible steel sleeves, where the glands operate. Stainless steel is also used for auxiliary and trip valve spindles, trip valve, and nozzles. The unit is equipped throughout

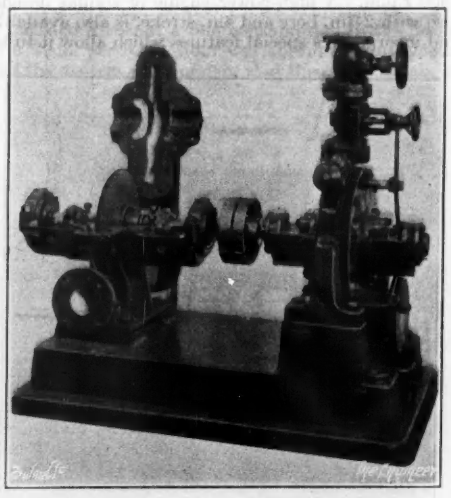


FIG. 47—TURBINE-DRIVEN PUMP—MIRRLEES

with ball and roller bearings, and its lubrication is therefore, it is claimed, unaffected by rolling of a vessel at sea.

Tangyes, Ltd.

The main exhibit on the stand of Tangyes, Ltd., of Cornwall Works, Birmingham, was a four-cylinder, vertical oil engine of the firm's latest V H type, with a designed output of 240 b.h.p. at 500 r.p.m. The engine—Fig. 50, page 350—was shown as a running exhibit. The cylinders each have a bore of 10¾in. with a stroke of 15in. Airless injection of fuel is employed, with a differential spring-loaded plunger-type sprayer and separate fuel pumps for each cylinder. Attention may be called to the complete enclosure of all working parts and the embodiment of the fly-wheel within the main casing of the engine. All the controls are conveniently arranged at the fly-wheel end of the engine. The lubricating system includes a chain-driven pump

drawing from the bed-plate sump, which delivers the oil through duplicate Auto-Klean filters. A complete water-cooling system, with an engine-driven pump, is used. The engine is silent in operation as the air is taken into the cylinders through passages cast in the cylinder head which draw from the large volume enclosed by the outer walls of the main engine frame. The compression pressure is 430 lb. per square inch, and the fuel consumption 0·39 lb. per b.h.p. hour at full and three-quarter loads. This type of engine is built in sizes of two to eight cylinders, ranging from 100 to 600 b.h.p. Other exhibits included a 30–36 b.h.p., three-cylinder marine engine with reduction and reverse gear, and a large range of pumps specially designed for marine use. The "Pneumo-Starter" exhibited on the stand aroused a good deal of interest on account of its compact nature. This device is intended for the starting of small multi-cylinder oil engines by the use of compressed air. The 2½in. by 3in. size has an overall length of less than 15in., and the distance from the axis of the starting spindle to the engine facing is under 2½in. Its weight is only 35 lb., complete with starting valve, and it is capable of starting multi-cylinder engines up to 9 litres in capacity when the air pressure available is 300 lb. per square inch. According to its makers, its performance is comparable with that of a 5in. diameter, 24-volt electric starter motor. Sectional drawings of the "Pneumo-Starter" are reproduced in Fig. 48, from which it will at once be seen that it works on the principle of a reversed gear pump. On first depressing the starting lever compressed air is admitted to the space A, where it acts upon the end of the main driving shaft. This shaft is splined where it passes through the driving gear wheel and is axially slidable. Thus, it is pushed outward, against the resistance of a return spring, so that the pinion mounted at the outer end comes into mesh with the toothed ring carried by the engine fly-wheel. When about half of the total travel has been completed a port is uncovered by the end of the shaft and the compressed air passes *viâ* the pipe B to the gear chamber, whence it is exhausted to atmosphere. It will be observed that the device is of great simplicity, having, in fact, only three moving parts, the two gear wheels and the splined driving shaft. Anyone with knowledge enough to make adjustments in the running of the engine or effect minor repairs to it, would be capable of tracing any fault that developed in the starter and putting the matter right. But on account of the simplicity of the device, the chance of a fault developing seems rather remote, particularly since the proper lubrication of the bearing surfaces has been duly studied. Being a "rotary" engine the "Pneumo-Starter" gives a torque having practically no cyclic irregularity and has thus much the same characteristics as an electric motor.

FIELDING AND PLATT, LTD.

There was shown on the stand of Fielding and Platt, Ltd., of Gloucester, the four-cylinder vertical oil engine illustrated by Fig. 52 on page 350, which is representative of a two-cylinder to six-cylinder unit with designed outputs of 60 to 180 b.h.p. at 400 r.p.m. The engine is a development of the firm's standard horizontal cold-starting engine, and special features of the design are the moderate compression pressure of 420 lb. per square inch, the low maximum pressure of 460 lb. per square inch, and the low fuel full-load consumption of 0·4 lb. per b.h.p.-hour. The engine has a bore of 9in., with a stroke of 14in., and at the standard 400 r.p.m., the piston speed is only 934ft. per minute. The Fielding and Platt fuel injection system, with the dual combustion chamber, employs a large diameter spray nozzle, and the fuel pump pressure does not exceed 800 lb. per square inch. As will be clear from our illustration, the engine is totally enclosed, and accessibility of working parts has been carefully taken into account. An important feature is the forced lubrication system, with a water-cooled bed-plate, which obviates the use of a special oil cooler, even when working in equatorial climates. The speed controls are grouped at the end of the engine, and work in conjunction with a centrifugal governor of the crankshaft type. This engine has been employed largely in the Australian gold-mining industry, in which reliability of operation and non-stop runs over long periods are essential features. For marine use the engines are built to comply with Lloyd's regulations for marine oil engine work.

RUSTON AND HORNSBY, LTD.

The stand of Ruston and Hornsby, Ltd., of Lincoln, was noteworthy for a series of oil engines, including the firm's latest designs of engines for marine propulsion and auxiliary services, and for industrial work. The principal exhibit was the six-cylinder, four-stroke, direct-reversing, marine oil engine, illustrated in Fig. 51 on page 350. It is similar to engines recently installed in the Thames tug "Rio," and the Grimsby trawler "British Columbia," but of slightly smaller size. The designed output is 320 b.h.p. at 430 r.p.m., and the cylinders have a bore of 11in., with a stroke of 14½in.

Reversing is effected by making the inlet and exhaust valves interchangeable in function. The reversing mechanism is housed in a special gear-box mounted at the after end of the engine immediately above the manœuvring wheel. By an arrangement of valves, compressed air is admitted to the cylinders to start the engine and to reverse the direction of rotation. The fuel pumps are interconnected with this mechanism and are automatically held out of action and put into operation by movements of the manœuvring wheel. Thus complete control is exercised through the single hand wheel, and all such complications as sliding cam shafts, &c., are avoided. The forced lubrication system is on the dry sump principle, and all wearing surfaces, including valve-rocking levers, are automatically lubricated. Both the water circulating and bilge pumps are driven at a reduced speed from the crankshaft at the forward end of the engine, and a two-stage compressor, which provides the manœuvring air, is also mounted at the forward end.

Other marine engines included a six-cylinder, 106 b.h.p. engine, with reverse and reduction gear, and a smaller 36 b.h.p., four-cylinder unit manufactured in association with R. A. Lister and Co., Ltd., also with reverse and reduction gear and electric starting. One of these engines was equipped with the new oil-operated reverse reduction gear, which is of very simple and compact design. There were two auxiliary engines, one a five-cylinder, 150 b.h.p. unit, driving a 100-kW generator, and the other a three-cylinder, 52 b.h.p., radiator-cooled generator unit, designed for emergency or port lighting duty.

Another interesting unit, which we illustrate in Fig. 49, was a four-cylinder, 264 b.h.p., horizontal oil engine, having a bore of 12½in. and a stroke of 22in., and a speed of 265 r.p.m. It is the largest of a range of sizes up to 264 b.h.p. The bed-plate casting of this engine is made in one piece, and special methods are employed in the machining operations to ensure correct alignment of cylinders and bearings. A patented fuel distributor, in order to ensure the carrying of equal loads by all cylinders, is fitted, and automatic lubrication is maintained by a positively driven submerged gear pump, which delivers oil under pressure to all main wearing surfaces. Starting is by compressed air admitted to all cylinders. There was also shown a series of starting air receivers, which, owing to their patented construction, are, it is claimed, capable of holding pressure indefinitely without leakage.

ELECTROMERSIBLE MOTORS AND PUMPS, LTD.

Examples of submersible pumping equipment for bore-holes and deep wells were to be seen on the stand of Electromersible Motors and Pumps, Ltd., of Abbey House, Westminster, S.W.1. The equipments consist of a multi-stage centrifugal pump combined with a three-phase, squirrel-cage motor, which will work in a "drowned" position below the pumping level. The motor is suspended on the delivery pipe and the current is conveyed to it by an insulated cable. No foot valve is required and priming is, of course, unnecessary. As the motor is at the lower end of the delivery pipe there is no long driving shaft. Moreover, as the arrangement is independent of the straightness of the bore-hole and does not call for special alignment, the pumps are simple and cheap to erect and can easily be removed for examination. The construction of the pump eliminates the use of glands and stuffing-boxes. No running joint has to be water-tight, and owing to the special windings water is allowed to pass through the motor, which is therefore capable of a large output for its size. In installing the pump for use in connection with a bore-hole, it is merely necessary to concrete round the top of the bore-hole lining tube, and then to set the headpiece on this as a foundation in a manhole below the floor for the suspension of the pump, the switchgear being placed wherever required on the surface. If necessary, the switchgear can, of course, be automatically operated by the level of the water in the delivery tank or reservoir, or in the well.

(To be continued.)

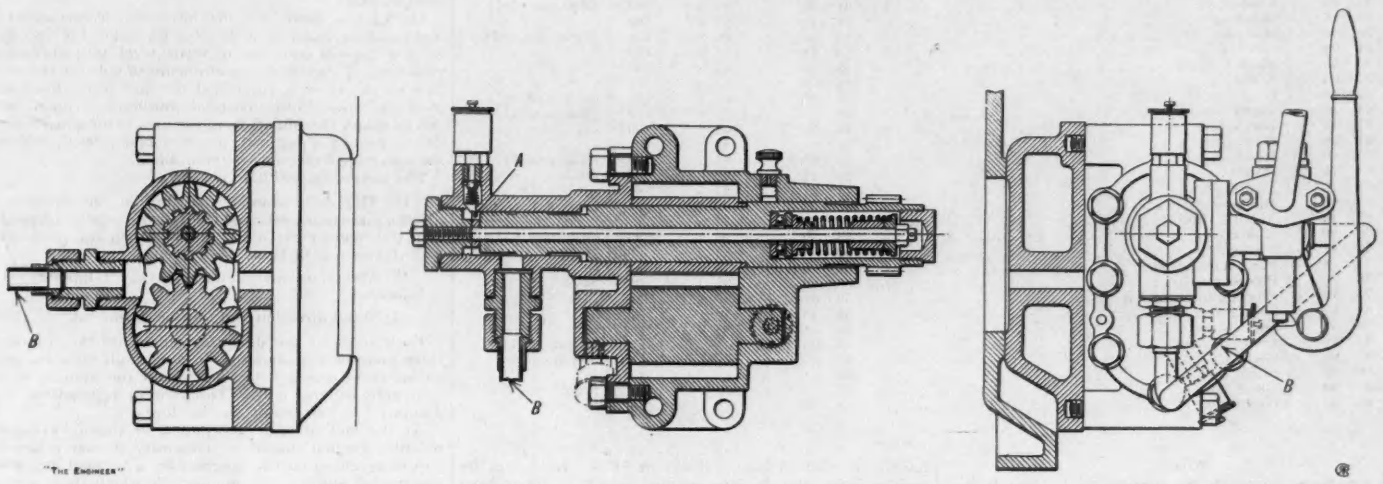


FIG. 48 SECTIONAL VIEWS OF "PNEUMO-STARTER"—TANGYE

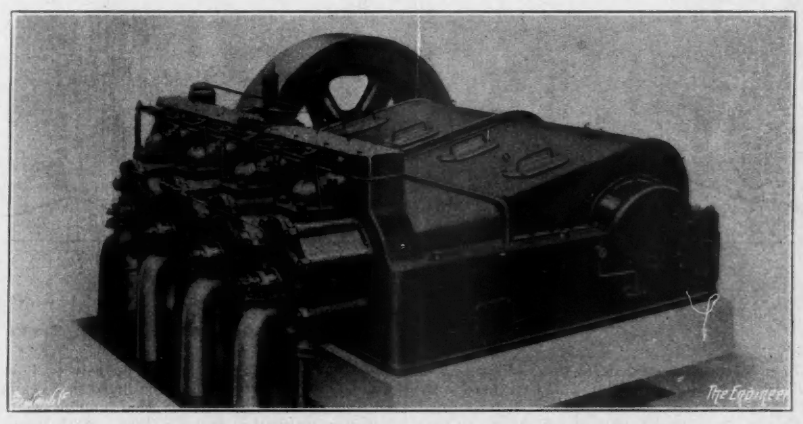


FIG. 49—264 B.H.P. HORIZONTAL OIL ENGINE—RUSTON

THE Edinburgh Corporation contemplates the erection of a benzole recovery plant at the Granton gasworks.

L.N.E.R. Silver Jubilee Train.

The official records and notes of the trial run of the "Silver Jubilee" train (L.N.E.R.) on Friday, September 27th, are as follows :—

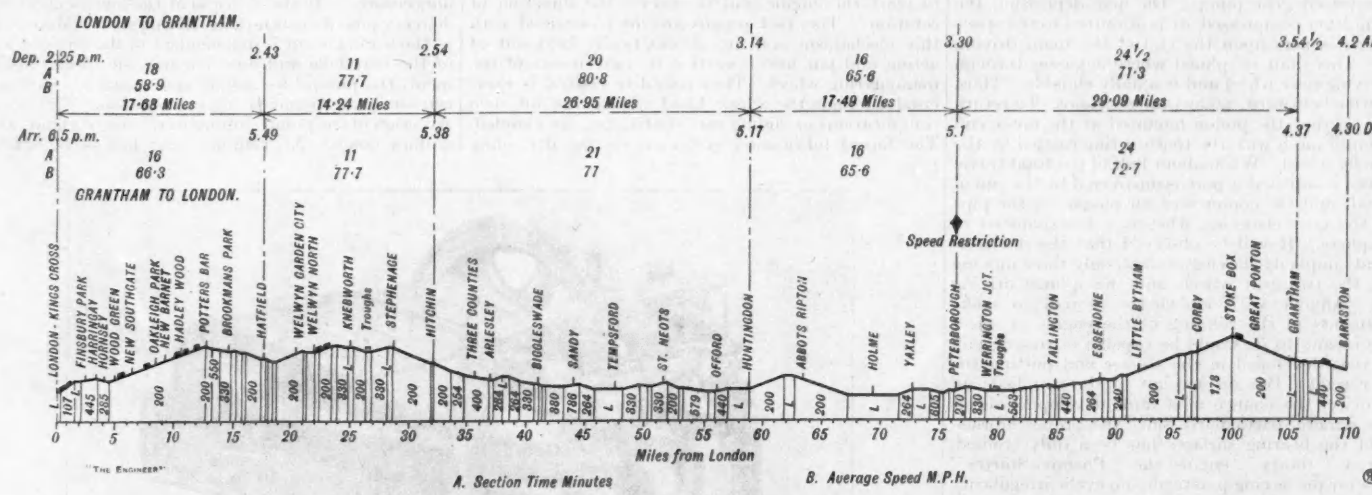
Engine No. 2509, *"Silver Link."* *Driver Taylor, Fireman Luty. Load, Seven Vehicles,* 220 *Tons Tare,* 230 *Tons Gross.*

Distance. Miles.	chains.		Times. min.	sec.	Average speeds, station to station. m.p.h.	Max. and min. speeds. m.p.h.	
0	00	King's Cross .. dep.	0	00	—	—	
2	41	Finsbury Park .. pass	4	42	32·1	—	
4	04	Hornsey .. „	6	22	55·4	—	
4	78	Wood Green .. „	7	11	68·0	70	
6	35	New Southgate .. „	8	26	70·2	71½	Acceleration
9	12	New Barnet .. „	10	43	71·3	72	up continuous
10	46	Hadley Wood .. „	11	53	73·3	74	1 in 200 gradient
12	57	Potter's Bar .. „	13	36	74·7	75	
14	51	Brookman's Park .. „	15	00	82·5	—	
17	55	Hatfield .. „	17	07	86·5	—	
20	25	Welwyn Garden City .. „	18	46	95·5	98	(Mile-post 19)
22	00	Welwyn North .. „	19	52	92·1	90	
23	39	Woolmer Green .. „	20	52	89·3	88	
25	03	Knebworth .. „	21	55	88·5	93½	(Mile-post 26½)
28	46	Stevenage .. „	24	13	92·3	90	
30	00	Mile-post 30 .. „	25	06	96·8	100	(First attained)
31	74	Hitchin .. „	26	14	101·9	107	
35	56	Three Counties .. „	28	20	107·9	109½	
37	03	Arlesey .. „	29	03	112·0	112	
41	12	Biggleswade .. „	31	22	106·8	105	(Mile-post 38½)
44	10	Sandy .. „	32	59	110·4	112	(Mile-post 43)
47	41	Tempsford .. „	34	50	109·9	109½	
51	58	St. Neot's .. „	37	13	106·0	104½	
55	00	Mile-post 55 .. „	39	03	107·2	109½	(Mile-post 54)
55	76	Offord .. „	39	41	90·0	85	Slack
58	70	Huntingdon .. „	41	41	87·5	88	
62	00	Mile-post 62 .. „	43	53	85·2	83½	(Top of 1 in 200)
63	42	Abbot's Ripton .. „	44	58	84·5	—	
69	29	Holme .. „	48	50	90·6	93½	(Mile-post 67½)
72	48	Yaxley .. „	51	08	84·5	80½	
74	78	Fletton Junction .. „	52	55	79·9	—	
76	29	Peterborough .. „	55	02	39·3	20	Slack
79	40	Werrington Junction .. „	59	07	46·1	—	
84	67	Tallington .. „	63	13	78·1	85	
88	52	Essendine .. „	65	58	83·2	—	
92	18	Little Bytham .. „	70	35	—	—	Signal check
97	08	Corby .. „	77	49	—	—	Signal check
100	09	Stoke Box .. „	80	51	—	—	
102	03	Great Ponton .. „	82	23	—	—	Signal check
105	37	Grantham .. arr.	88	15	—	—	

Notes.

A maximum speed on the journey of 112 m.p.h. was reached twice, once near Arlesey and once between Biggleswade and Sandy. Between mile-posts 30 and 55 (where brakes were applied for Offord curves), the speed was entirely at or over 100 m.p.h. This distance of 25·0 miles was covered in 13 min. 57 sec., at an average of 107·5 m.p.h.* From Hatfield to Huntingdon, a distance of 41 m. 15 ch., was covered in 24 min. 34 sec., at an average of 100·6 m.p.h. throughout.* The entire distance covered at an average speed of 100 m.p.h. continuously was approximately 43 miles.*

From Wood Green to Fletton Junction, the distance of precisely 70 miles was covered in 45 min. 44 sec., at an average of 91·8 m.p.h.† Fletton Junction marks the beginning of the severe slack through Peterborough Station. On the continuous 8 miles at 1 in 200 rising from mile-post 4½ (Wood Green) to Potter's Bar, the speed steadily accelerated from 70 to 75 m.p.h. The signal checks from Little Bytham onwards were due to the special train having overtaken the York and Harrogate express which had left King's Cross at 1.40 p.m., 45 min. earlier. Apart from these delays, Grantham would have been reached without difficulty in 80 min. from London.



PROFILE OF LINE, LONDON—GRANTHAM, TIMES AND SPEEDS

SIXTY YEARS AGO.

Our issue of October 1st 1875 contains an account of the precursor of an engine which was to become famous in the history of steam motive power—the Willans single-acting engine with three or four cylinders. This engine, as our readers are aware, set a new standard as regarded absence of noise and smooth running in high-speed steam engines and achieved great popularity until a rival appeared in 1890 in the form of Belliss and Morcom's double-acting high-speed engine with forced lubrication. The Willans engine for a time fulfilled the demand, which was then arising, for an engine which would run quickly enough to drive a dynamo directly, without the use of belting or intermediate gearing. That demand, however, can hardly be said to have existed in 1875. Indeed in its earliest days the Willans engine seems to have been applied principally for driving steam launches. In our article we stated that engines of the type described had been fitted by Messrs. Willans and Ward, of 51, Lincoln's Inn-fields, in a number of launches on the Thames including Sir Gilbert East's "Ella" and the Marquis of Exeter's "Isis." These engines were of about 40 i.h.p. and apparently had three cylinders. A four-cylinder Willans engine had been fitted in the "Black Angel" a small launch built for Willans and Ward by Edwards and Symes of North Greenwich. That launch we recorded had attained a speed of about 13 miles an hour. The most powerful Willans engine so far made was, however, one of about 80 h.p. which had been fitted in a vessel of about 35 tons. The cylinders of that engine were 10in. in diameter and had a stroke of 12in. With steam at 70 lb. the speed was 240 r.p.m. We described the engine as consisting of three cylinders the piston of one of which acted as the valve of one of the others. Each piston had a steam chamber formed in it to which steam was supplied through a hollow rod—serving also as a guide to the piston—which, opening out of the steam chamber in the piston, extended upwards into a steam chest formed as part of the cylinder cover. At a certain point in the downward stroke of the piston a port in its steam chamber registered with a port in the cylinder wall. Steam thereupon flowed from the steam chest down the hollow guide rod through the ports and along a passage into one of the other cylinders. On the upstroke of the piston the cylinder port was uncovered and the steam in the second cylinder exhausted through the crank case. A single valve controlled the starting, stopping and reversing of the engine. As the engine was single acting, the thrust, so we stated, was always in one direction and there was no knock however loose the bearings might be. Mr. Willans, we said, believed that he could obtain with his engine three times the piston speed commonly reached by small engines of the ordinary type. . . . It will be recognised that this early form of Willans engine differed from that which ultimately became famous in that it did not employ an air cylinder, arranged in tandem with the steam cylinder. This air cylinder was added by Willans to prevent the reversal of the thrust on the crank pin which, in spite of our remarks to the contrary, did occur in the earliest design.

* World's railway record, so far as can be authenticated, for either Diesel or steam propulsion.

† World's record for steam traction.

River Flow Records.

Diagrams for the River Dee, representing the day-to-day records of the water levels at the Cairnton station of the Aberdeen Water Authority and the flows at Woodend gauging station, 1 mile upstream, from a catchment area of 528 square miles, have been prepared by River Flow Records, Parliament Mansions, S.W.1. They also represent the meteorological records of rainfall, temperature, and wind on the same area. At Woodend, with the most perfect apparatus existing in this country, velocities have been measured at every 5ft. to 10ft. across the river and at each 6in. or 1ft. of depth from surface to bottom. These measurements were continued from July to December, 1934, for all stages of the river from summer low level up to high floods, only exceeded during the year by one flood in April.

During the floods the measurements were carried on night and day, and for a range of water level of 7ft. there are few gaps of over 3in. of water level with unrecorded velocities. From these measurements of velocity the whole flow of the river is computed for any water level, and from the water levels recorded continuously on a clock-driven graph the run-off from the area is obtained for any day or part of a day and for any longer period, provided the water level records are maintained.

The meteorological data consist of—

(1) The daily rainfall distribution on the area of 528 square miles, assessed from the records of ten gauges, in the manner explained previously in the publication of the records of 1934.

(2) Maximum and minimum daily temperatures at Balmoral.

(3) Wind direction and force at Balmoral.

Each sheet of the diagrams represents the records of three months, and shows the run-off from the area aggregating from January 1st, 1935, and the amount of the aggregate at any date. The rainfall aggregating from January 1st is shown by another line.

At the end of each dry period in these six months' records, residual run-off or temporary storage is assessed and represented on the diagram by a vertical line above the run-off graph. The amount by which these vertical lines fail to reach the rainfall aggregate is an estimate of the loss of rainfall. Such losses are reckoned at the end of each dry period, and are spread uniformly over the intervening dates, providing estimated values of temporary storage during the rain periods.

It is necessary not to write off these losses too liberally, as the records already show that on the Dee there is a high return of saturation during dry periods, which may reduce the losses very considerably, especially in the winter months.

This aggregate diagram is easily applicable to water supply areas with reservoir storage and supply draw-off; in such cases there will be an aggregate of supply plus reservoir storage below the run-off graph, and it will fall short of the run-off graph by the amount of compensation water plus overflow.

A diagram of all the data for each day is also given.

A study of the records during one and a half years on the Dee seems to indicate that rainfall is under-estimated. There is no actual measurement on the high mountains, and it may be said that the rainfall measured in a rain gauge is generally under-measured.

A note in the *Electrical Review* says that the Bolivian Government has signed a contract with the Hochschild Company, a South American development organisation, for the construction at Titicaca Lake, 12,500ft. above sea level, of one of the biggest hydro-electric plants in Latin America. The plant will be able to supply electricity not only to Bolivia, but also to neighbouring countries. The company contemplates the complete drainage of Lake Titicaca towards Sorato, 6400ft. above sea level, where the plant will be built. It is expected that the plant will allow of the electrification of the Bolivian railways, as Bolivia does not produce coal.

Rail and Road.

THE three railway trades unions decided on September 25th to make joint and immediate representations to the railway companies for the restoration of the remainder of the wages "cuts" made in 1931.

THE London and North-Eastern Railway Company reports that this year the "Flying Scotsman" has made the non-stop run of 393 miles between London and Edinburgh, and *vice versâ*, on 120 occasions. It has covered 47,000 miles, with a loss of only 3 min. on its booked timing. On only two occasions was it late in arriving at its destination, and the delay in each case was due to permanent way operations.

THE railways census, mentioned herein on September 20th, shows that the increase from 524,729 to 529,710 is spread over a very wide area, by small additions, offset occasionally by minor decreases. There are, for instance, 258 more drivers, 39 more firemen, and 315 additional engine cleaners. There was an increase of 22 in the permanent way men, and of 463 in the shop and artisan staff. On the other hand, there was a decrease of 349 in the number of signalmen.

THE two additional sections in the Southern Company's suburban area that are to have electrical services, as related herein on December 14th last, were brought into use on Monday, September 30th. They are between Nunhead and Lewisham Junction and between Woodside and Sanderstead. The former line will provide facilities for trains from the Bexleyheath and Dartford loop line to run into St. Paul's Station and thus relieve Cannon-street and Charing Cross stations.

IN *The Times* of September 17th, under the heading "Campaign Against Noise," appeared a letter from Professor Henry Spooner, in which he singled out the tube railways for special criticism. The cause there, he claimed, was very noisy propelling machinery, and, to some extent, the fact that wheels, rails, and rail joints were not as perfect as they should be. This letter called forth a reply the following day from the Public Relations Officer of the London Passenger Transport Board, in which was recited what had been done to reduce the number of rail joints and to line the tunnel walls with noise-absorbing materials. Experiments have been made, too, with the rolling stock, and the later types are undoubtedly quieter than the old.

THE apparent inconsistency of some of the two-hour trains between London and Birmingham, and *vice versâ*, by the alternative G.W. and L.M.S. routes, starting from their respective stations at about the same hour, has been the subject of considerable correspondence in *The Times*. The complaint would, however, appear to have been disposed of by the letter on September 27th from Mr. H. L. Wilkinson, the Superintendent of the Line, G.W.R., who said, quite recently, that the matter was discussed at a meeting between representatives of the Birmingham Chamber of Commerce and the companies concerned, when it was agreed that, having regard to the general requirements of the traffic by either company's route, the existing arrangements were satisfactory, as borne out by the loading of the trains on both routes.

HEREIN, on September 13th, we mentioned, in relation to the Great Western Centenary, the history of the Bristol and Gloucestershire Railway. On the same day—June 19th, 1828—that that line was sanctioned, there was also authorised the Gloucester and Avon Railway, which was for a line from the Kennet and Avon Canal at Keynsham to Rodway Hill, Mangotsfield, where it was to join the aforesaid Bristol and Gloucestershire line. Both railways were originally of 5ft. gauge, but when the latter line passed into the influence of the Great Western it had to provide for the broad gauge also. The Act—283 Vic. c. 56—ordered that that was to be done by the extra rail being outside the 5ft. gauge, *i.e.*, with three running rails. Brunel, however, did not do that; he laid transverse sleepers for two rails at 5ft. gauge inside longitudinal timbers carrying the 7ft. gauge rails. The inner rails were laid in 2in. higher than the outer rails, and when the siding connections, which were of 5ft. gauge, were used, the wheels had to jump over a gap that had necessarily to be made at the intersection of the inner and outer rails. When the line was inspected prior to its opening on July 8th, 1844, the Board of Trade Inspector spoke of the arrangement as being of a very objectionable character, and "highly dangerous to the safety of the public travelling on the Bristol and Gloucester line."

THE report, issued on September 27th, by Colonel Woodhouse, on the collision of April 26th last between a passenger train and a motor car, in which an occupant of the latter was killed, related to a type of level crossing that is rarely met with in connection with railway accidents. The scene of this fatality was the level crossing adjacent to Minster-on-Sea Station, on the Queenborough and Leysdown branch of the Southern Railway, which, as was the case at Jacob's Gutter-lane, mentioned herein on March 29th, is on a light railway. Though a public road level crossing, gates were, under the Light Railways Act, exempted. At four similar crossings on the branch gates were required, and they have since been provided at two other crossings. These gates stand normally across the railway, and vehicular traffic is thus free to pass over the crossing, except when a train is approaching. The closing of the gates against road traffic to allow a train to pass is done by a member of the train crew—usually the guard—and for this operation the train should stop on one side of the crossing. That, as will be understood, was not done at Minster-on-Sea, but there was an unofficial arrangement whereby the porter at the station flagged trains that passed whilst he was on duty over the crossing. The man's hours of duty did not, however, extend over the whole of the day, and he was not on duty when—7.10 p.m.—this accident happened. The driver of the car, who was a local resident, had been accustomed to being flagged, and so she crossed just as the train—the view of which was badly obscured by a hedge—approached. Colonel Woodhouse recommends that if the station work at Minster does not justify a member of the staff being on duty for the whole time that trains are running, the crossing be provided with gates similarly to the six other crossings on the branch.

Miscellanea.

PLANS for a domestic wireless telephone service as well as one with foreign countries are in hand in China. The first service to be installed will link up the more important cities, such as Shanghai, Nanking, Hankow, Tientsin, and Peking, and it will be extended next year.

THE sludge digestion plant at Airdrie sewage purification works has been officially opened. The plant, constructed under a German patent, is the first of its kind in Scotland. The tank holds 400,000 gallons, and the sludge produces 180,000 cubic feet of gas per month.

AT the annual meeting of the Staveley Coal and Iron Company the chairman stated that it was intended to erect a plant for the manufacture of sodium chlorate. There is no plant in the British Isles for making sodium chlorate at the present time, and the company is confident that it can successfully compete with Colonial and Continental manufacturers.

THE revised electrical regulations for New Zealand have been completed, and it has been made an offence to manufacture, offer for sale, or sell any apparatus which does not comply with the requirements of the regulations. It is also an offence to install or use any material or apparatus not in accordance with the regulations. Power is given to prohibit the use of any appliance or apparatus considered hazardous.

THE exploitation of the U.S.S.R. iron deposits at Kursk, estimated at 330 million tons, has been started. Some 205 million tons are estimated to have an iron content of 53 to 58 per cent. The completion of the Moscow-Donetz Basin railway, which is at present under construction, will facilitate the transportation of the Kursk ore to Tula, Kosogorsk and other places. When the industrialisation of the Kursk district is completed the Soviet Union will have a third metallurgical centre in addition to those at present existing in Krivoy Rog and in Kuznetsk Basin.

ONE of the most serious fires in London for many years broke out about 3.30 p.m. on Wednesday, September 25th, in an eight-storied warehouse at Colonial Wharf, High-street, Wapping. Besides river floats and water towers forty engines were called into action and some 400 firemen employed. The fire broke out on the top storey and spread downwards till by 8.30 it had reached the foundations undermining the wall fronting the river, which collapsed, burying three lighters aground outside. Five lighters were destroyed. The new fire float, the "Massey Shaw," described in a Seven-day Journal note of April 26th last, proved of great service, her high-pressure water gun enabling good work to be done even when the tide forced her to move to midstream.

ACCORDING to a note in the *Chemical Trade Journal*, trials on anti-corrosive paints for ships' bottoms have been carried out over six summer months in Osaka Harbour by Mr. S. Oshima. The inorganic materials examined included the following:—Lead arsenate, arsenic, calcium silicofluoride, barium silicofluoride, sodium silicofluoride, zinc silicofluoride, and zinc dust. In no case was anything above a very moderate degree of anti-fouling efficiency found. The organic materials investigated included tobacco powder, pyrethrum powder, naphthalene, camphor, phenol, rotenone, diphenylamine, hexachlorethane, dinitrocresole, and nicotine sulphate. All these materials were found to be of no practical value when used alone, although they did seem somewhat to improve the efficiency of anti-fouling compositions based on cuprous oxide.

FOR the purpose of defining contours of the bed of the reservoir at Boulder Dam, aerial photographs are being taken each time the water in the reservoir rises 20ft. These 20ft. contours will furnish a guide for a topographic map with 5ft. contours to be used in studying the progressive silt accumulations in the reservoir. In this work the world's largest aerial camera is taking the largest photographs ever made. The camera developed by Fairchild Aerial Surveys, which is described in *Engineering News Record*, consists of two five-lens camera units installed in a special mounting. One camera is set at an angle of 45 deg. to the other, so that the ten prints secured with each tripping of the master shutter control overlap to make an octagonal composite print; from an elevation of 30,000ft., 760 square miles of ground area are included in one composite photo. By taking in such a wide expanse of territory the camera becomes particularly useful in securing ground control points for accurate mapping. The assembled camera unit with film roll weighs 275 lb. The ten rolls of film needed for a single loading weigh 70 lb., and include 1200ft. of film, sufficient for 2000 individual photographs or 200 composites of ten exposures each. Each set of ten prints measures 32in. by 32in. The ten shutters are operated electrically at the same instant. Should any of the shutters fail to function properly a small neon light flashes a warning signal.

A NOTE in the *Journal* of the Franklin Institute gives an account of a paper read by Mr. Ivar Hole before the Canadian Gas Association, in which he described an apparatus that may be useful in cities with a surplus of cheap electricity, where the demand for gas exceeds the capacity of the gasworks. The apparatus, developed by a Norwegian firm, produces water gas from anthracite and steam. It consists principally of a vertically placed cylinder lined with fire-brick and filled with carbonaceous material, which is charged at the upper end. Steam is introduced at the lower end and the gas taken out at the top. The electric energy is introduced near the bottom and at the top through carbon electrodes (Söderberg). Single-phase current is used. The first generator put into operation uses 250 kW and produces about 6000 cubic feet per hour. The second has a continuous load of 400 kW and produces 10,000 cubic feet per hour. Gas is composed principally of CO (48 per cent. vol.) and H_2 (51 per cent. vol.), and has a calorific value of 310 B.Th.U. per cubic foot. It contains very little dust and is easily cleaned. The carbon material used in these generators is anthracite lumps not exceeding 4in., with an ash content of about 3 per cent.; 18 lb. of anthracite are used per 1000 cubic feet of dry gas, exclusive of a small loss in ash. Any low-ash coke of sufficient mechanical strength, also charcoal, is equally usable. The amount of steam required per 1000 cubic feet of moist gas is 26 lb. to 28 lb.

Air and Water.

TWENTY-NINE aerodrome sites are either under construction or have been recently completed in New Zealand.

THE "Olympic" is expected to arrive in the Tyne to be broken up on Sunday, October 13th. The work of demolition is expected to extend well over a year.

THE new French liner "Ville d'Alger" has attained a speed of 23 knots on her trials. This vessel is intended for the Compagnie Générale Transatlantique's Marseilles-Algiers service.

THE recent high winds have no doubt played an important part in the establishing of a new record time on the Croydon–Cologne air route, when the Imperial Airways, "D.H. 86, Gypsy 6" machine covered the distance in 115 minutes.

A SOVIET pilot, Victor Yevseyev, has flown a single-seater aeroplane into the stratosphere, reaching a height of 39,384ft. The time between his leaving the ground and landing again was ninety minutes. At times the temperature during the flight was 92 deg. below freezing point.

IT is reported that the United States Post Office is inviting tenders for the transport of air mail across the Pacific from San Francisco to Canton, with calls at Honolulu and Manila. It is specified that there shall be a weekly service each way. The service should be in operation at the end of next year, as the closing date for tenders is October 21st.

AN analysis of the casualty returns compiled by the Liverpool Underwriters' Association shows that during August there were 113 collisions, 72 strandings, 58 cases of machinery damage, 31 fires, 22 cases of weather damage, one sinking, and 83 unclassified casualties. Three British steamers were totally lost, and three foreign steamers and one foreign motorship. The figures for motor and steam tonnage lost are 12,661 tons and 4753 tons respectively.

A NEW paddle steamer of the "Princess Elizabeth" type, with modifications, has been ordered by the Southampton, Isle of Wight, and South of England Royal Mail Steam Packet Company from John I. Thornycroft and Co., Ltd. The new ship, which is to be ready for service next spring, will be 195ft. in length, and will be propelled by compound diagonal engines. She will be of the general utility type capable of use on passage and excursion work, as well as a tender for dealing with liner traffic.

FLYING a Pratt and Whitney Wasp-engined Lockheed "Vega" aeroplane, Lieutenant F. Waitkus recently flew from Long Island, U.S.A., to Ballintrobe, Co. Mayo, Ireland, in about 22½ hours. He intended flying to Kovno, Lithuania, 800 miles farther on, but was forced down by lack of petrol. In making his landing approach he stalled the "Vega" a few feet from the ground and damaged it considerably. Over the Atlantic he had experienced icing up of wings and carburetter. This makes the twenty-fourth west-to-east crossing of the Atlantic.

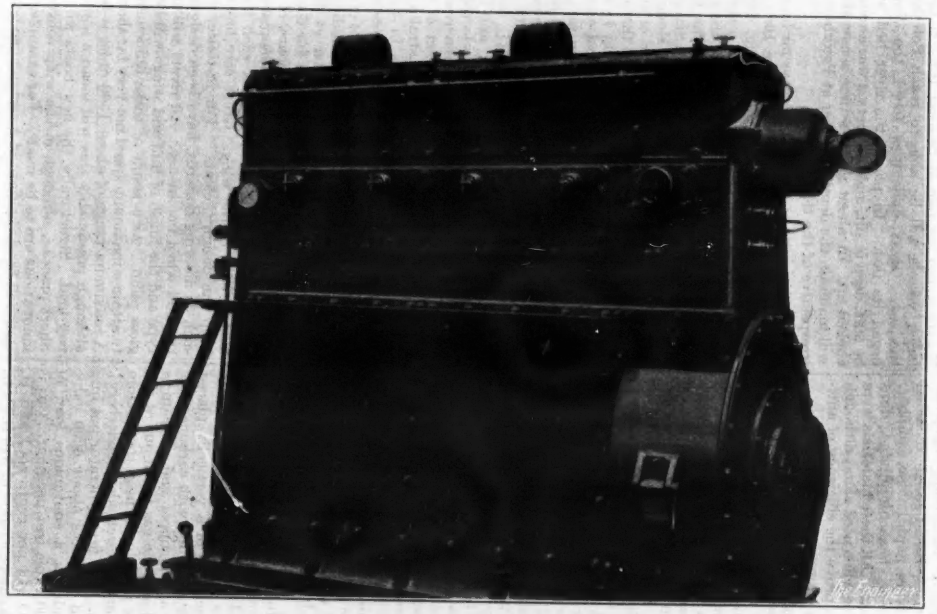
IN ten years the Nene Catchment Board plans not only to have a navigable river from the Wash to Peterborough, but also a depth of 7ft. from Peterborough inland to Northampton capable of floating 100-ton barges. Much larger vessels will be able to reach Peterborough from the sea. Great difficulties faced the Board when it began its task. In places the river bed was found to be 60ft. deep in silt, and in others it was almost completely choked up. In about a year's time a new sluice and lock will maintain the depth of water at Peterborough at 12ft., irrespective of the tide.

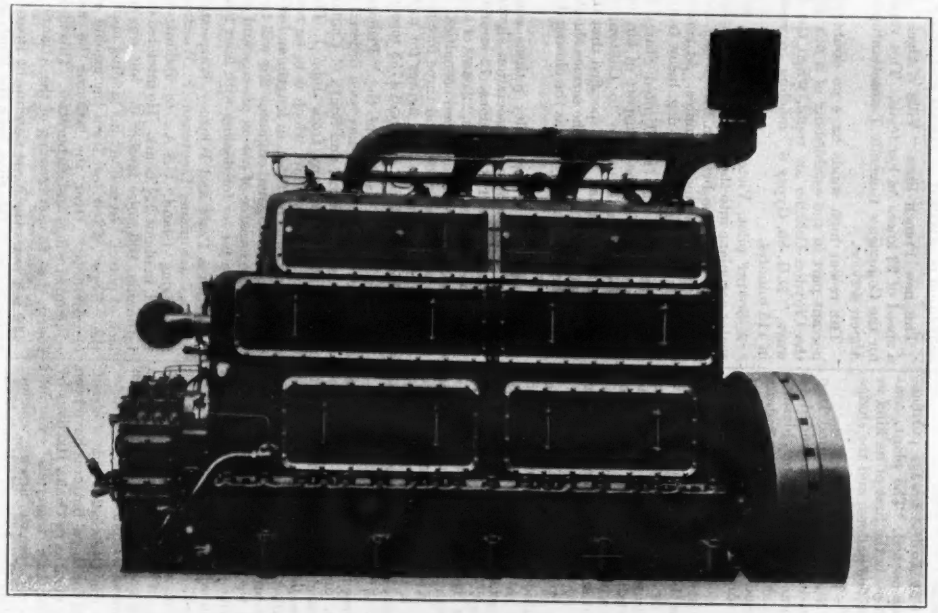
THE four-engined Imperial Airways air liner "Dorado," left Croydon on Monday, September 16th *en route* for Penang, British Malaya. From Penang, during October and November, this air liner will make a series of survey and experimental flights with a view to the provision of a regular connecting air service between the England–Australia route and Hong Kong, China. Six return flights are to be made between Penang and Hong Kong. The first return flights will be in the nature of aerial surveys, and each single journey will occupy three days, while the remaining four return flights, taking 1½ days for each single journey, will be to gain practical experience as to the operation of a Penang–Hong Kong service on a permanently commercial scale, and connect with Imperial Airways London–Singapore service at Penang. The air route to be followed in these test flights will be from Penang to Saigon, French Indo-China; from Saigon to Tourane, also in French Indo-China; and from Tourane on to Hong Kong. Penang has been selected as the point of contact with the England–Australia route because it has been found that, in the operation of existing time schedules on the main England–Australia service, connections with these main air mails in both directions can be made at Penang with the least possible delay.

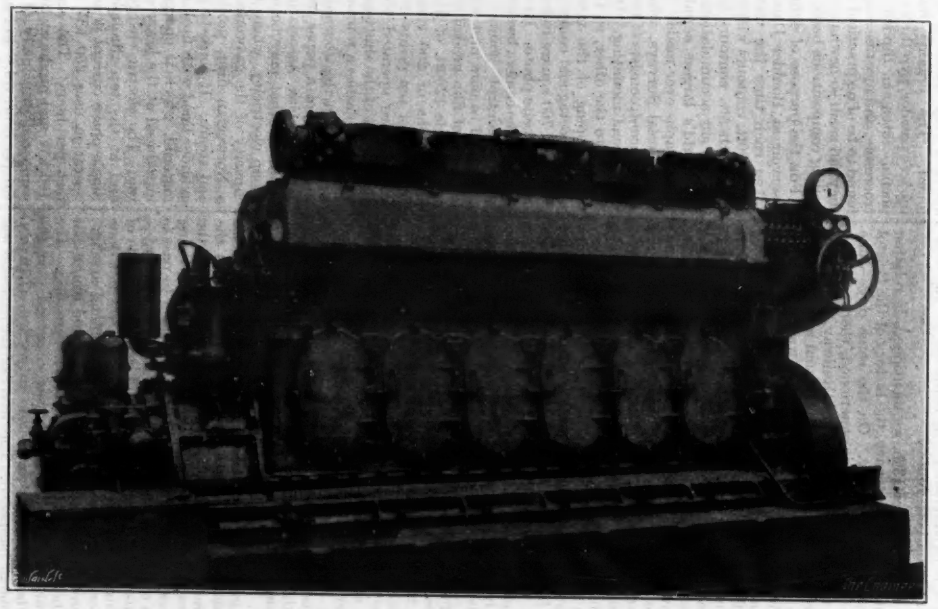
A NUMBER of details are given in *Flight* of the new large flying boats which Short Brothers are building at Rochester for Imperial Airways, Ltd. Known as Empire boats, from the fact that they are intended for the long Empire air routes of the near future, these boats, of which several are being built, are cantilever monoplanes, with four engines arranged abreast, two on each side, along the leading edge of the wing. Great care has been taken to keep the design "clean." For instance, all projections, such as mooring bollards, have been designed to slip into the hull when not in use. All rivets will be of the flush type and the finish of hull and wings will be in very high-gloss paint. As a result of these refinements it is hoped to attain a maximum speed not very far short of 200 m.p.h. A maximum range of about 1500 miles is being aimed at, although presumably this will mean a somewhat reduced pay load. Structurally, the new boats will follow normal Short practice, although in the wing construction certain innovations are to be made. For example, the main wing spar will be in the form of a rectangular box, with corners of extruded sections and a covering of light alloy. To the front and back of this single box spar the leading and trailing edges will be attached. Wing flaps of special design will be incorporated. The new boats, which should be ready in the spring, will have an overall length of 88ft. 6in., with a wing span of 114ft. When the machine is on its beaching chassis the overall height will be about 30ft. The gross weight will be 40,000 lb.

OIL ENGINES EXHIBITED AT OLYMPIA

(For description see page 344.)







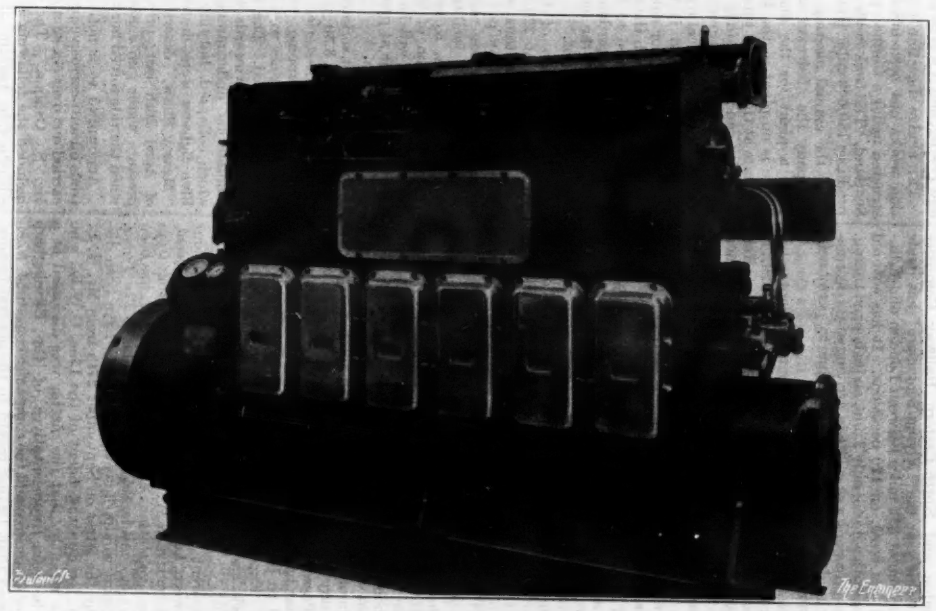


FIG. 50 (ABOVE)—240 B.H.P. FOUR-CYLINDER ENGINE—TANGYE
FIG. 51 (BELOW)—320 B.H.P. SIX-CYLINDER ENGINE—RUSTON

FIG. 52 (ABOVE)—120 B.H.P. FOUR-CYLINDER ENGINE—FIELDING AND PLATT
FIG. 53 (BELOW)—300 B.H.P. POPPET-VALVE ENGINE—MIRRLEES

The Engineer

OCTOBER 4, 1935.

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NOTICES TO READERS.

**** If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

**** For Subscription rates, see page 2 of Advertisements.*

**** All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

**** No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGES OF ADDRESS.

**** Will subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

HIGH SPEED ON THE RAIL.

We may safely assume that fifty million people now know that on Friday last a speed of one hundred and twelve miles per hour was attained on a British railway with an ordinary steam locomotive, an ordinary passenger train weighing two hundred and thirty tons, on an ordinary road, under ordinary climatic conditions. Of these millions most have learnt of this achievement through the sensational accounts of the run presented in the daily Press, or the broadcast by the B.B.C., which was rendered even more sensational by the dramatic skill of the announcer, who contrived to make it almost as exciting as Captain Wakelam's running commentary on an international Rugby match. One wonders, indeed, what Captain Wakelam would have done with the trip had he been on the train with his eye fixed on the speedometer and his mouth at the microphone! Now we do not want to depreciate in any way the services which these accounts have performed for British railways and the steam locomotive. Probably in no other way could a just appreciation of the high achievement have been awakened in the public mind. But the plain fact is that, save to the dozen or so persons who were grouped about the speedometer, there was nothing whatever sensational in the run. To the hundred or more other passengers it would have appeared just like any other express run had they not been expecting an unusual phenomenon and seeking for it, rather vainly and inaccurately, with their watches. We say this because we believe it to be a far higher compliment to the new train than reports which strive to make it appear that the miraculous was accomplished. It cannot be repeated too often that there is nothing inherently impossible, or even very difficult, in the attainment of high speeds on British railways with locomotives and trains of the familiar kind. Mr. Gresley designed a special engine for this train, but save for the streamlined cover in which it is enclosed, and the raising of the boiler pressure from 220 lb. to 250 lb., it is very similar to any other "Pacific" built by him. It will not be forgotten that one of his old "Pacifics," built in 1923, made a speed of 100 miles per hour last November with a train of 205 tons behind the tender. In fact, the new locomotive is an ordinary steam express engine of the most recent design. We stress that point because it does seem to us very essential that people should know that the familiar steam locomotive—the cheapest and simplest and lightest in upkeep of all kinds of locomotives—can do whatever may be achieved in the way of speed by exceptional designs.

To many observers the most notable characteristic of the "Silver Link" and of her immediate sister "Quicksilver" is the streamlining on the Bugatti, or horizontal, system. What effect this streamlining had on last Friday's run, or will have upon the runs at more moderate speeds in the regular service which opened last Monday, it is much too early to say. It is understood that Mr. Gresley has had a series of wind tunnel tests made of different streamline forms. But the making of such tests of model trains and locomotives is encompassed by great difficulties and uncertainties. It is to be hoped that some day Mr. Gresley will publish the details of his experiments. Frankly, we shall be surprised to hear that they had any great effect on the design. One need only look at any illustration of the engine to see that once the Bugatti principle of a horizontal instead of a vertical wedge had been decided upon the rest followed naturally upon past experience. As far as the streamlining of the train is concerned, the same thing may be said. It has been very ingeniously smoothed out as far as circumstances would permit, and gaps between the coaches—well-known offenders—have been closed. But on the other hand, no attempt has been made to reduce the drag caused by the flat rearward end of the last coach. A moment's consideration shows the impossibility of attacking that important detail in the resistance. Those who thought about it may have received an object lesson on Friday last, when at the end of the outward journey the locomotive was transferred from one end of the train to the other. No more need be said. But besides body streamlining Mr. Gresley has made an attempt to grapple with the undercarriage air resistance by fitting petticoats between the bogies of the coaches. The part that they may play in reducing—or increasing—air resistance will be watched with exceptional interest. The importance of such petticoats or curtains was demonstrated in a series of tests carried out in Canada on a model locomotive and tender and reported in our issue of April 14th, 1933. But it is impossible to simulate the come-day go-day conditions on an open railway by any wind tunnel experiments so far discovered, and it may prove—we hold our judgment in complete suspension—that when all things are considered the petticoats are more trouble than they are worth. Let us say emphatically that the technical interest in this train is not the high average speed at which it is to be run—a speed which with a similar train could be attained and is attained by unstreamlined engines—but the reduction of power and consequently of coal and water consumption which it is hoped may be achieved by streamlining. Unfortunately, Mr. Gresley has no strictly comparable engine running on the same service, but he may, nevertheless, be able, at the end of a year or so, to satisfy himself that streamlining, by reducing head resistance, has actually resulted in more economical running.

To conclude we must say a few words about the train itself and the trial run. Of the train it is quite impossible to speak too highly and everyone concerned in its design, construction, and decoration is deserving of the highest praise. It is an essentially English corridor train with all the characteristics which the taste of the British travelling public requires, and it has been carried out to afford the greatest comfort to the body and pleasure to the eye. On another page we give a schedule of the timing, and a contour of the road without which the timings cannot be fully appreciated. On the down run several new railway records were set up. They have not been equalled by any other train as far as is known. They are a continuous run of twenty-five miles at an average speed of 107·5 m.p.h.; a similar run of 41 miles at an average speed of 100·6 m.p.h., and a run of 43 miles at an average speed of 100 m.p.h. To these we may add the accomplishment of running 70 miles, between Wood Green and Fletton, at 91·8 m.p.h., which is claimed to be a record for steam locomotives. A no less interesting fact, as showing the capacity of the engine, is that she increased her speed up the 1 in 200 bank to Potters Bar from 70 m.p.h. to 75 m.p.h. The up run, owing to circumstances which could not be controlled, was noteworthy, but not remarkable. What it did demonstrate was that at moderate high speeds—between seventy and eighty-five miles an hour—the train and the road were well suited to each other. The running was very smooth and pleasant. If we had to select any particular speed for commendation we should be inclined to put it between seventy-five and eighty miles an hour. At that speed the running was so smooth that one was quite unconscious of the high velocity. At higher speeds, ninety and over, it became increasingly evident that parts of the road are not really suited to them. It is a mere truism to say that if express trains are, in the future, to be run at one hundred miles an hour or so the road will have to be redesigned to suit them. Here and there one came to stretches of line on which any speed might be attained with comfort, but they were straight lengths in perfect condition. At other places and at very high speed, if we applied our test—walking the length of the train along the corridor and counting the bruises at the end—the running showed that the road and the train were not in complete harmony. Even then, however, it was the severity of the test which showed up the defects, for if one remained seated there were very few instances in the whole run, even at the highest speeds, when the passenger was conscious of even passing discomfort. In all this we are, of course, speaking relatively. This train must be compared with itself and its peers. We measure its defects by departure from perfection, not by comparing them with the common experience on more ordinary trains. One question in conclusion, "What will Mr. Collett and Mr. Stanier do now?"

Road Breaking.

Of all the noises that affront the ears of those who work in cities, there is none more exasperating than the reverberating roar of the pneumatic road-breaker. The mind can soon grow unconscious of the continuous rumble of ordinary street traffic, and even the passing of some particularly noisy vehicle, or the now happily infrequent sound of a motor horn will hardly cause more than a momentary distraction. But the noise of the pneumatic drill is in a class by itself. Its shattering blasts of sound, with their sudden beginnings and abrupt endings, render concentration of thought impossible and destroy all hopes of serious work by those within range of the nuisance. This is a fact which is beyond argument. Those who suffer from the din caused by the periodical destruction of the concrete road foundations outside their shops or offices are not to be conciliated by measurements of the noise in decibels, nor by statements as to its apparent intensification by reverberation from the walls on either side of the street. Their grievance is a genuine one, and neither scientific measurements nor explanations can serve in any way to mitigate the offence to their ears or nerves. What they want is that the nuisance should be stopped. The growing intolerance of the public towards unnecessary noise has already made itself felt in many directions, and the pneumatic drill, as used for road breaking, cannot much longer escape either reform or extermination. As we have often remarked, those who insist that the engineer shall not be permitted to create a nuisance by any of his works are really the truest friends of engineering. The standards they set may be difficult to attain and their attitude may be anything but helpful, but in principle they are undoubtedly right. The pneumatic road-breaking drill can, at times, be an intolerable nuisance. The prohibition of apparatus of the kind is generally considered impracticable, for there is, so far, no alternative method of road breaking equal in speed and cheapness. The tendency, therefore, is to demand that road-breaking drills, and, incidentally, the compressors that drive them, should be made to do their work with reasonable quietness. To this end experiments are now being made with the use of silencers, but whether these will suffice to reduce the noise to the limit that the occupiers of adjacent premises have the right to expect is still an open question. One may always hope for success along these lines, although the very nature of a pneumatic drill, operating as it does by a rapid succession of hammer blows, is hardly consistent with silent working.

So far, as is usual in discussions of the noisiness of road-breaking operations, it has been taken for granted that there is some necessity for the periodical renewal of the concrete foundations

upon which the road surface is laid. To many it remains a mystery why it should really be necessary to destroy and replace, at comparatively short intervals, thousands of yards of what ought to be permanent concrete work. Road surfaces, of course, will wear, but there is no wear in the proper sense of the word upon the foundations. In a typical London street the surface consists of wooden blocks carefully laid on a smooth bed of concrete. The blocks will inevitably deteriorate under the influence of traffic and weather, and it is only to be expected that they will require periodical renewals. But with the concrete foundations it is another matter. They are presumably designed to support the weight of the traffic, and they are protected from injury by their substantial and resilient wooden covering. Under such conditions it is fair to ask why the foundations of a road should have to be torn up after the lapse of a few years. Concrete itself is amongst the most durable materials known, and there seems no reason why a concrete road foundation should not have an indefinite life if properly constructed and adequately protected. Unfortunately, experience shows that their life is far from indefinite. Every autumn the roar of the road breakers in their efforts to destroy all the costly work of a few seasons before makes life in the neighbourhood hideous. It is impossible to believe that it is technically impossible to construct a really permanent road foundation. To do so might be a little more costly than the present practice, but it could hardly be so expensive in the long run. If inadequate design or unsuitable material is responsible for the present short-lived work, the duty of engineers is plain. It may be that better protection from the impact of the traffic loads transmitted through the covering is needed, and if this be the case surely some better protection could be provided. In whatever direction the solution is to be sought, the problem should not remain unsolved. The periodical cutting out of thick beds of concrete, the average quality of which is made evident by the power required for its destruction, is as painful to contemplate as the accompanying din is outrageous to the ears.

No one with any engineering instincts can regard such proceedings without a feeling that something must be wrong with a system which apparently makes them necessary. Many people, unfortunately, do not possess such instincts, but however indifferent the general pul lic may be to the waste involved, they are quite capable of appreciating the fact that there would be none of the noise to which they object so strongly if the foundations did not have to be broken up. Those engaged in the present campaign against unnecessary noise might well consider this aspect of the question, for the provision of really permanent road foundations would do more for quietness than the most effective silencers that could be devised for pneumatic drills. Furthermore, since such repairs as were necessary would then only involve the renewal of the wooden or other surface of the road, the time during which a street had to be closed for traffic would be appreciably shortened. The quantity of materials to be hauled to and from the site would also be diminished, and all who occupied premises along the street or used it as a thoroughfare would be spared much of the irritation which they are compelled to suffer at present. We do not think that any competent civil engineer would deny the possibility of making a permanent foundation for a roadway, and with a little insistence on the part of the public this great reform in practice might be brought about. In a Gilbertian world one could imagine a modern Pooh-Bah earning the applause of the harassed citizens by ordaining that the life of his road surveyors should never exceed that of their road foundations. While deprecating such a drastic plan at the present day, we would make a plea on behalf of all who suffer from the periodical upheavals and racket caused by road breaking, for more durable construction than is customary at present.

The Third International Steam Tables Conference.

THE following Report of the Third International Steam Tables Conference has just been issued.

The Third International Steam Tables Conference was held in the United States of America during the week commencing September 17th, 1934, at the invitation of the Special Research Committee on the Thermal Properties of Steam of the American Society of Mechanical Engineers. Its purpose was to improve and to extend international agreement on the properties of steam in continuation of the work of the London Conference of 1929 and the Berlin Conference of 1930.

The following were present :—Great Britain : Mr. H. L. Guy, Manchester ; Mr. A. C. G. Egerton, F.R.S., Oxford ; Mr. G. S. Callendar, London ; Mr. I. V. Robinson, London. Germany : Prof. Dr.-Ing. F. Henning, Berlin ; Prof. Dr.-Ing. E. Schmidt, Danzig-Langfuhr; Prof. Dr.-Ing. H. Hausen, Munich ; Dr.-Ing. W. Koch, Munich ; Dr.-Ing. F. Michel, Swarthmore, Pa. United States : Dr. Harvey N. Davis, Hoboken, N.J.; Dr. Frederick G. Keyes, Cambridge, Mass.; Dr. Nathan S. Osborne, Washington, D.C.; Prof. Joseph H. Keenan, Cambridge, Mass.; Dr. H. C. Dickinson, Washington, D.C.; Mr. G. A. Orrok, New York, N.Y.; Dr. L. B. Smith, Cambridge, Mass.; Prof. F. O. Ellenwood, Ithaca, N.Y.; Prof. R. C. H. Heck, New Brunswick, N.J.; Mr. C. B. LePage, New York, N.Y. Czechoslovakia : Represented by Mr. I. V. Robinson. Dr.-Ing. Erich J. M. Honigmann, of Vienna, Austria, was present through the Conference as a visitor.

The first session of the Conference was opened at the National Bureau of Standards in Washington, D.C., by Dr. Lyman J. Briggs, Director of the Bureau. Greetings from the engineering societies of the United States were extended by Mr. Fred M. Feiker, Secretary of the American Engineering Council. The proceedings of the Conference then continued under the chairmanship of Dr. Alex. Dow, Chairman of the A.S.M.E. Special Research Committee on the Thermal Properties of Steam.

After the necessary formal business had been completed, a committee was formed, in accordance with the procedure followed at previous conferences, to revise and enlarge the International Skeleton Tables. This committee consisted of the entire British and German delegations and Messrs. Osborne, Keyes and Keenan, with Messrs. Heck and Ellenwood as alternates for the American members.

After adjournment of the first meeting of the Conference, Dr. Osborne explained and exhibited the apparatus employed at the National Bureau of Standards for measurement of properties of saturated liquid water and saturated water vapour. The methods and technique of measurement were demonstrated later when Dr. Osborne and his associates executed a typical experiment.

The second session of the Conference was held on Tuesday, September 18th, at Massachusetts Institute of Technology in Cambridge, Mass., where the delegates were greeted by Dr. Karl T. Compton, President of the Institute. At this session Dr. James A. Beattie, Associate Professor of Physico-Chemical Research, gave an address on the preliminary results of his experimental investigation of the relation between the international scale of temperature and the thermodynamic scale from the ice point to the sulphur boiling point. Afterwards Dr. Keyes and Dr. Smith exhibited the apparatus and explained the methods of measurement which they used to determine the specific volume of superheated steam and compressed liquid water. Dr. Keyes showed also the apparatus he is using for measuring the Joule-Thomson coefficient and the constant temperature coefficient.

At the third session of the Conference, which was held on Wednesday, September 19th, at the headquarters of the American Society of Mechanical Engineers in New York, N.Y., Dr. Calvin W. Rice,* Secretary of the Society, welcomed the delegates. The Conference then adjourned subject to call by the Chairman for the final session later in the week.

The committee met immediately thereafter and elected Mr. I. V. Robinson chairman. It undertook during the next three days the revision and extension of the Skeleton Table of the Berlin Conference in the light of the new experimental and analytical data which were presented by the various delegates.

The skeleton table No. I adopted compares with the Berlin Conference Table as follows :—

(*a*) The saturation pressure, enthalpy or total heat and specific volume of saturated liquid and saturated vapour are given at forty-two different temperatures —the Berlin Conference gave these values at ten different temperatures.

(*b*) The enthalpy or total heat and specific volume are given for seventy-two different states of superheated steam—the Berlin Conference gave these values at fifty-seven different states.

(*c*) The enthalpy or total heat and specific volume are given for eighty-seven different states of compressed liquid water—the Berlin Conference gave no values for the compressed liquid.

(*d*) At temperatures above 200 deg. Cent. the tolerances on properties of saturated liquid and saturated vapour are reduced to $\frac{1}{2}$ to $^1/_{10}$ of the Berlin Conference values.

(*e*) Tolerances on the specific volume of superheated vapour at pressures above 100 kg./sq. cm. are generally about $^1/_5$ per cent. of the volume—the Berlin Conference values were 1 to 3 per cent.

(*f*) Tolerances on enthalpy or total heat of superheated vapour are reduced to about $\frac{1}{4}$ the Berlin Conference values.

The final session of the Conference was held on Saturday, September 22nd, at the American Society of Mechanical Engineers. Dr. Harvey N. Davis presided at this session in the absence of Dr. Dow. The report of the committee was presented by its chairman, Mr. Robinson, and was accepted by the Conference. The following resolutions were unanimously adopted :—

Resolved : That it is the hope and desire of this Conference that the experimental investigation of the properties of water should be continued in order to utilise the equipment and *personnel* of the several contributing institutions to the best advantage. It is desired that the enthalpy or total heat measurements of superheated steam be continued at the Imperial College of Science, London, and in Czechoslovakia, and extended as far in the range of temperature and pressure as is practicable, and that other independent investigations of this field should be encouraged. The Conference records its appreciation of the assurances of the British delegation that this work will be carried out.

It is desired that new measurements of the saturation pressure of steam between 0 and 100 deg. Cent. be undertaken at the Reichsanstalt, Berlin, and at the National Bureau of Standards, Washington, and the Conference records its appreciation of the assurance of the German delegation that their section of the work will be carried out. It is desired that Dr. Koch may be able to continue his measurements of the heat capacity of the liquid and gaseous phases of water.

It is desired that the measurements on the rate of change of enthalpy or total heat of superheated steam with pressure be continued at the Massachusetts Institute of Technology, Cambridge, and that the possibility of carrying out similar measurements on the liquid phase be likewise considered, and the Conference records its appreciation of the assurances of the Massachusetts Institute of Technology representatives that this work will be carried out.

It is desired that new measurements of the enthalpy or total heat of water between 0 and 100 deg. Cent. be undertaken at the National Bureau of Standards to provide greater accuracy in these values for use in other calorimetric measurements.

It is further desired that additional measurements of latent heat between 0 and 50 deg. Cent. be under-

TABLE A.—*Pressure Conversion Table.*

Units.	Atm.	Kg./cm.².	Lb./in.².	Bar.	Mm. Hg.
1 atmos. ..	1	1·033228	14·6959	1·013250	760
1 kg./cm.². .	0·967841	1	14·2233	0·980665	735·559
10 lb./in.². .	0·68046	0·70307	10	0·689476	517·149
1 bar. ..	0·986923	1·019716	14·5038	1	750·062
1 m. Hg. ..	1·31579	1·35951	19·3368	1·333224	1000

TABLE B.—*Energy Conversion Table.*

Volume Conversion Factors : 1ft.³ = 28316·8 cm.³ = 28·3161 litres. *Specific Volume :* 1 cu. ft./lb. = 0·062428 m.³/kg. 1 m.³/kg. = 16·0185 cu. ft./lb.

Units.	Joules.	Kg. m.	Ft.-lb.	Int. J.	Int. whr.	I.T. cal.	B.Th.U.	lb./in.² × ft.³	Atm. × dm.³
10^4 Joules	10000·0	1019·72	7375·62	9997·0	2·77694	2388·17	9·4770	51·2196	98·6923
100 Kg. m.	980·665	100·0	723·30	980·371	0·272325	234·20	0·92938	5·02293	9·67841
10^4 ft.-lb.	13558·2	1382·55	10000·0	13554·1	3·7650	3237·9	12·8491	69·4444	133·809
10^4 Int. Joules	10003·0	1020·02	7377·8	10000·0	2·7778	2388·9	9·4799	51·235	98·722
10 Int. whr.	36011·0	3672·1	26560·0	36000·0	10·0	8600·0	34·1275	184·446	355·40
10^3 I.T. cal.	4187·3	426·99	3088·4	4186·05	1·16279	1000·0	3·9683	21·447	41·3255
10 B.Th.U.	10551·8	1075·99	7782·6	10548·7	2·93019	2519·96	10·0	54·046	104·138
10^3 lb./in.² × ft.³ ..	195238·0	19908·7	144000·0	195179·0	54·216	46626·0	185·027	1000·0	1926·85
100 Atm. × dm.³ ..	10132·5	1033·23	7473·35	10129·5	2·81374	2419·8	9·6026	51·898	100·0

1 Litre × atm. = 1·000027 atm. × dm.³ 1 Kg./cm.² × m.³ = 10000 Kgm.

* Deceased, October 2nd, 1934.

TABLE I.—*Properties of Saturated Liquid Water and Saturated Vapour.*

Temp. deg. Cent.	Pressure, kg./cm.²	Tolerance, ±	Specific volume. Liquid cm.³/g	Tolerance, ±	Vapour, cm.³/g.	Tolerance, ±	Enthalpy or total heat. Liquid, I.T. Cal./g.	Tolerance, ±	Vapour, I.T. Cal./g.	Tolerance, ±
0	0·006228	0·000006	1·00021	0·00005	206,310	210	0*	0	597·3	0·7
10	0·012513	0·000010	1·00035	0·00010	106,410	110	10·04	0·01	601·6	0·7
20	0·023829	0·000020	1·00184	0·00010	57,824	58	20·03	0·02	605·9	0·6
30	0·043254	0·000030	1·00442	0·00010	32,922	33	30·00	0·02	610·2	0·5
40	0·075204	0·000038	1·00789	0·00010	19,543	19	39·98	0·02	614·5	0·5
50	0·12578	0·00006	1·0121	0·0002	12,045	12	49·95	0·03	618·9	0·5
60	0·20312	0·00010	1·0171	0·0002	7,678·3	7·7	59·94	0·03	623·1	0·5
70	0·31775	0·00016	1·0228	0·0002	5,046·3	5·0	69·93	0·03	627·3	0·5
80	0·48292	0·00024	1·0290	0·0002	3,409·2	3·4	79·95	0·04	631·4	0·5
90	0·71491	0·00036	1·0359	0·0002	2,361·5	2·4	89·98	0·05	635·3	0·5
100	1·03323	Nil	1·0435	0·0002	1,673·2	1·7	100·04	0·05	639·1	0·5
110	1·4609	0·0010	1·0515	0·0004	1,210·1	1·2	110·12	0·06	642·7	0·5
120	2·0245	0·0013	1·0603	0·0004	891·65	0·89	120·25	0·06	646·2	0·5
130	2·7544	0·0016	1·0697	0·0004	668·21	0·67	130·42	0·07	649·6	0·5
140	3·6848	0·0021	1·0798	0·0004	508·53	0·51	140·64	0·07	652·7	0·6
150	4·8535	0·0032	1·0906	0·0004	392·46	0·39	150·92	0·08	655·7	0·7
160	6·3023	0·0042	1·1021	0·0004	306·76	0·31	161·26	0·08	658·5	0·8
170	8·0764	0·0053	1·1144	0·0004	242·55	0·24	171·68	0·09	661·0	0·8
180	10·225	0·007	1·1275	0·0004	193·80	0·19	182·18	0·09	663·3	0·9
190	12·800	0·008	1·1415	0·0004	156·32	0·16	192·78	0·10	665·2	0·9
200	15·857	0·008	1·1565	0·0004	127·18	0·13	203·49	0·10	666·8	0·9
210	19·456	0·008	1·1726	0·0004	104·24	0·10	214·32	0·11	668·0	0·9
220	23·659	0·009	1·1900	0·0004	86·070	0·086	225·29	0·11	669·0	0·9
230	28·531	0·010	1·2087	0·0004	71·483	0·071	236·41	0·12	669·4	0·9
240	34·140	0·012	1·2291	0·0004	59·684	0·060	247·72	0·12	669·4	0·9
250	40·560	0·013	1·2512	0·0004	50·061	0·050	259·23	0·13	668·9	0·9
260	47·866	0·015	1·2755	0·0004	42·149	0·042	270·97	0·18	667·8	0·9
270	56·137	0·017	1·3023	0·0004	35·593	0·036	282·98	0·19	666·0	0·9
280	65·457	0·020	1·3321	0·0004	30·122	0·030	295·30	0·20	663·6	0·9
290	75·917	0·022	1·3655	0·0005	25·522	0·030	307·99	0·20	660·4	0·9
300	87·611	0·024	1·4036	0·0005	21·625	0·035	320·98	0·30	656·1	1·0
310	100·64	0·03	1·4475	0·0005	18·300	0·035	334·63	0·40	650·8	1·2
320	115·12	0·03	1·4992	0·0005	15·438	0·035	349·00	0·50	644·2	1·4
330	131·18	0·04	1·5619	0·0005	12·952	0·035	364·23	0·60	636·0	1·6
340	148·96	0·04	1·6408	0·0005	10·764	0·035	380·69	0·70	625·6	1·8
350	168·63	0·04	1·7468	0·0006	8·802	0·035	398·9	0·8	611·9	2·0
360	190·42	0·05	1·9066	0·0040	6·963	0·040	420·8	0·8	592·9	2·0
370	214·68	0·05	2·231	0·021	4·997	0·100	452·3	1·5	559·3	3·0
371	217·26	0·10	2·297	0·026	4·761	0·100	457·2	1·5	553·8	3·5
372	219·88	0·11	2·381	0·034	4·498	0·110	462·9	2·2	547·1	4·0
373	222·53	0·11	2·502	0·053	4·182	0·120	471·0	3·5	538·9	4·5
374	225·22	0·11	2·79	0·15	3·648	0·120	488·	5·	523·3	5·0

Observed values of critical temperature :
M.I.T. 374·11 C.
Reichsanstalt 374·2 ± 0·1 C.
* By definition.

TABLE II.—*Specific Volume of Compressed Liquid Water and Superheated Steam* (cm.³/g.).
Of each pair of figures the upper represents the accepted value and the lower the tolerance (±).

Pressure, kg. per sq. cm.	Temperature, deg. Cent. 0	50	100	150	200	250	300	350	400	450	500	550
1	1·00016	1·01210	1730·0	1975·0	2216·0	2454·0	2691·0	2928·0	3164·0	3400·0	3636·0	3872·0
	0·00005	0·00020	1·0	2·0	2·0	2·0	3·0	3·0	3·0	3·0	4·0	4·0
5	0·9999	1·0119	1·0432	1·0906	433·8	484·1	533·2	581·6	629·6	677·4	725·0	772·5
	0·0002	0·0002	0·0002	0·0002	0·4	0·5	0·5	0·6	0·6	0·7	0·7	0·8
10	0·9997	1·0117	1·0431	1·0902	210·4	237·6	263·3	288·2	312·7	337·0	361·1	385·1
	0·0002	0·0002	0·0002	0·0002	0·2	0·2	0·3	0·3	0·3	0·3	0·4	0·4
25	0·9989	1·0110	1·0422	1·0893	1·1556	89·0	101·1	112·1	122·6	132·7	142·7	152·6
	0·0002	0·0002	0·0002	0·0002	0·0003	0·1	0·1	0·1	0·1	0·1	0·1	0·2
50	0·9977	1·0099	1·0409	1·0877	1·1532	1·2495	46·41	53·12	59·05	64·60	69·92	75·10
	0·0002	0·0002	0·0002	0·0002	0·0003	0·0004	0·07	0·08	0·09	0·09	0·10	0·12
75	0·9965	1·0088	1·0397	1·0861	1·1508	1·2452	27·48	33·22	37·78	41·83	45·62	49·25
	0·0002	0·0002	0·0002	0·0002	0·0003	0·0004	0·05	0·07	0·08	0·08	0·09	0·10
100	0·9952	1·0077	1·0385	1·0845	1·1485	1·2410	1·3979	23·03	27·05	30·41	33·45	36·32
	0·0002	0·0002	0·0002	0·0002	0·0003	0·0004	0·0007	0·05	0·05	0·06	0·07	0·07
125	0·9940	1·0067	1·0372	1·0829	1·1462	1·2369	1·3877	16·66	20·53	23·52	26·14	28·55
	0·0002	0·0002	0·0002	0·0002	0·0003	0·0004	0·0007	0·03	0·04	0·05	0·05	0·06
150	0·9929	1·0056	1·0360	1·0814	1·1439	1·2330	1·3782	11·98	16·10	18·90	21·25	23·36
	0·0002	0·0002	0·0002	0·0002	0·0003	0·0004	0·0007	0·02	0·03	0·04	0·04	0·05
200	0·9905	1·0035	1·0337	1·0784	1·1395	1·2255	1·3612	1·671	10·31	13·05	15·11	16·87
	0·0002	0·0002	0·0002	0·0002	0·0003	0·0004	0·0007	0·002	0·02	0·03	0·03	0·03
250	0·9882	1·0015	1·0314	1·0755	1·1353	1·2184	1·3462	1·604	6·366	9·46	11·39	12·96
	0·0002	0·0002	0·0002	0·0002	0·0003	0·0004	0·0007	0·002	0·013	0·02	0·02	0·03
300	0·9859	0·9995	1·0291	1·0726	1·1312	1·2117	1·3327	1·557	3·02	6·98	8·90	10·35
	0·0002	0·0002	0·0002	0·0002	0·0003	0·0004	0·0007	0·002	0·01	0·02	0·02	0·02
350	0·9837	0·9975	1·0269	1·0698	1·1272	1·2054	1·3207	1·521				
	0·0002	0·0002	0·0002	0·0002	0·0003	0·0004	0·0007	0·002				
400	0·9814	0·9956	1·0247	1·0670	1·1234	1·1994	1·3097					
	0·0002	0·0002	0·0002	0·0002	0·0003	0·0004	0·0007					

Compressed liquid water — Superheated steam.

The specific volume of the liquid at 4 C, at a pressure of one atmosphere is 1·000027.

TABLE III.—*Enthalpy or Total Heat of Compressed Liquid Water and Superheated Steam* (*I.T. cal./g.*).
Of each pair of figures the upper represents the accepted value and the lower the tolerance (±).

Pressure, kg./sq. cm.	Temperature, deg. Cent. 0	50	100	150	200	250	300	350	400	450	500	550
1	0·023	49·97	639·2	663·2	686·5	710·1	734·0	758·0	782·4	807·2	832·3	857·8
	0·005	0·03	0·5	0·5	0·6	0·6	1·2	1·2	1·2	1·2	1·2	2·0
5	0·120	50·05	100·11	150·92	681·9	706·7	731·5	756·1	780·8	805·9	831·3	856·9
	0·505	0·03	0·05	0·08	1·0	1·0	1·2	1·2	1·2	1·2	1·2	2·0
10	0·240	50·15	100·20	151·00	675·1	702·1	728·0	753·5	778·9	804·5	830·1	855·9
	0·005	0·03	0·05	0·08	1·0	1·1	1·2	1·2	1·2	1·2	1·2	2·0
25	0·599	50·45	100·46	151·21	203·6	687·8	718·0	746·3	773·3	800·0	826·5	852·6
	0·005	0·03	0·05	0·08	0·1	1·1	1·2	1·2	1·2	1·2	1·2	2·0
50	1·20	50·96	100·90	151·58	203·8	259·2	698·4	732·9	763·1	791·6	819·9	847·3
	0·01	0·03	0·05	0·08	0·1	0·1	1·2	1·2	1·2	1·2	1·2	2·0
75	1·79	51·46	101·34	151·95	204·1	259·2	672·6	717·6	752·1	783·2	813·1	841·8
	0·01	0·03	0·05	0·08	0·1	0·1	1·2	1·2	1·2	1·2	1·2	2·0
100	2·39	51·96	101·78	152·32	204·3	259·2	320·5	699·5	740·0	774·5	806·0	836·1
	0·01	0·03	0·05	0·08	0·1	0·1	0·3	1·2	1·3	1·3	1·3	2·0
125	2·98	52·46	102·22	152·69	204·6	259·3	319·9	676·7	726·9	765·2	799·1	830·3
	0·01	0·03	0·05	0·08	0·1	0·1	0·3	1·2	1·3	1·3	1·3	2·0
150	3·57	52·96	102·65	153·06	204·8	259·3	319·3	646·8	712·1	755·3	791·8	824·4
	0·01	0·03	0·05	0·08	0·1	0·1	0·3	1·5	1·3	1·3	1·3	2·0
200	4·74	53·96	103·57	153·82	205·2	259·4	318·4	393·1	676·5	733·4	776·0	812·0
	0·01	0·03	0·05	0·08	0·1	0·1	0·3	0·8	2·0	2·0	2·0	2·5
250	5·90	54·96	104·46	154·57	205·8	259·5	317·6	387·6	622·5	707·5	758·8	798·9
	0·01	0·03	0·05	0·08	0·2	0·2	0·3	0·8	2·5	2·5	2·5	3·0
300	7·05	55·96	105·35	155·33	206·2	259·7	317·0	384·0	524·5	677·5	739·7	
	0·01	0·03	0·05	0·08	0·3	0·3	0·3	0·8	3·0	2·5	2·5	

Compressed liquid water — Superheated steam.

taken at the National Bureau of Standards to complete the series of these values.

An invitation extended by the Masaryk Academy of Work to hold the Fourth International Steam Tables Conference in Prague, Czechoslovakia, was accepted by unanimous vote of the Conference. In accordance with precedent established at the London and Berlin Conferences, the Secretariat will be transferred from the American Society of Mechanical Engineers to the Masaryk Academy of Work when the business of the Third Conference is completed.

The Skeleton Table adopted by the Third International Steam Tables Conference, which supersedes the Berlin Conference Table of 1930, is given herewith. The limits fixed by its accepted values and tolerances constitute a criterion, internationally agreed upon, by which the reliability of a steam table may be judged.

SKELETON TABLE ADOPTED BY THE THIRD INTERNATIONAL STEAM TABLES CONFERENCE, SEPTEMBER, 1934.

UNITS AND CONVERSION FACTORS.

Definitive Values :

1. Length : 2·54000 cm. = 1 in.
2. Mass : 453·5924 grammes = 1 lb.
3. Pressure :
   (*a*) One standard atmosphere = pressure of 76 cm. mercury column (density 13·5951 g./cm.³, gravity 980·665 cm./sec.²).
   (*b*) One bar = 10^6 dynes per cm.².
4. Energy :
   (*a*) 1000 international steam table calories (I.T. cals.) = 1/860 international kilowatt hour.
   (*b*) 1 international electrical watt = 1·0003 absolute watts.
   (*c*) 1 British thermal unit = 251·996 I.T. cal.
5. Temperature :
   All temperatures are expressed in terms of the International Temperature Scale. Where Kelvin temperatures were used the values were obtained by adding 273·16 to the temperatures on the International Scale.

On the basis of the above values the conversion tables A and B on the preceding page have been derived.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

HIGH-SPEED, TWO-CYCLE C.I. ENGINES.

SIR,—In view of the interest manifested in small Diesel engines, particularly in regard to the possibility of using this type of prime mover in private cars, we would like to suggest that there are two lines of development which do not appear to have received the attention that they deserve.

Large, slow-running Diesel power units of the two-cycle type, from about 20 h.p. per cylinder upwards, are singularly successful, but little or nothing seems to have been done to develop small and fast-running oil engines on the two-cycle principle apart from the Junkers opposed piston design and certain marine units which are heavy and operate at relatively low speed.

Possibly the advisability of fitting a pump for exhaust scavenging, rather than to utilise the crank case for this purpose, is a problem which most designers have preferred to avoid. Our investigations indicate, however, that there is every likelihood of the same reversion from four-cycle to two-cycle design with small engines as has already happened with large Diesel power units.

Another line of investigation would appear to be in the direction of air cooling. It would seem that the Krupp air-cooled compression-ignition power unit is successful, and for certain classes of work air cooling offers attractive possibilities.

We believe that the only serious difficulty which aircraft engine manufacturers have experienced in their investigations in this direction is to provide adequate cooling of the fuel injector.

It is essential that this component should not become overheated, and so long as this condition can be fulfilled the air-cooled Diesel engine presents such obvious advantages that the matter deserves early attention.

BARIMAR, LTD.,
C. W. BRETT,
London, September 25th. Managing Director.

LONG-SPAN BRIDGES.

SIR,—In answer to the inquiry of your correspondent "Bridget" as to the longest span in bridge construction, it is certain that the record belongs to the Golden Gate suspension bridge at San Francisco, with its span of 4200ft. between centres of towers. Its towers are completed and the wires for the cables are being strung. Next to this ranks the Hudson River suspension bridge at New York, opened in 1931, and having a span of 3500ft.

Wheaton, Illinois, U.S.A., E. E. R. TRATMAN.
September 16th.

THE coal hydrogenation plant of Imperial Chemical Industries at Billingham-on-Tees will be formally opened by Mr. Ramsay MacDonald on October 15th.

The Iron and Steel Institute.

No. III.

(*Concluded from page 325, September 27th.*)

ON Wednesday, September 18th, a paper on "The Use of the Hele-Shaw Apparatus in the Investigation of the Flow of Metals" was presented by Mr. A. M. Herbert and Professor F. C. Thompson. We give below the authors' *précis* and their conclusions.

STREAMLINE FLOW IN METALS.

The Hele-Shaw apparatus has been used by engineers in the study of streamline flow of fluids with interesting results. So far as the authors are aware, however, no attempt has hitherto been made to use it in the investigation of the deformation of metals. Since it appears that these materials also flow in a streamline fashion both in hot and in cold working, a study has here been made concerning the correspondence which may be obtained between the flow lines obtained with the apparatus and those actually found in the metals themselves. Typical drop forgings, tubes, and particularly wire have been investigated and the degree of agreement is good. It would therefore appear that it is legitimate to employ this type of apparatus where the mode of flow during any process of deformation is required to be known. In the design of the dies for the production of drop forgings, for instance, it is probable that invaluable evidence could be obtained of a kind which is not otherwise readily available. The authors reach the following conclusions :—

The authors have in the present paper shown how the Hele-Shaw apparatus may be employed, not only to obtain a qualitative picture of the manner in which metals flow during deformation, but also the extent to which quantitative data can be obtained. The latter part of the work, which is concerned entirely with the drawing of wire, results in the prediction of wave fronts which are in complete agreement with those obtained by actual drawing. Further, the results indicate that the effect of the contour of the die on the extent to which the centre flows in advance of the surfaces coincides with that obtained in a totally different manner by Thompson and Barton, and with the general experience of those concerned with the production of wire itself. Without making too strong claims at the present time, it is felt that the cumulative evidence presented is sufficient to justify the belief that, qualitatively, and at any rate to some considerable extent quantitatively, the method which has been described agrees with actual fact. The ease with which the streamlines can be obtained makes the method qualitatively of real practical utility, although it should be pointed out that the analysis of the results where quantitative information is required is a distinctly tedious process. The fact that a two-dimensional solution is all that can be obtained by this process must be borne in mind, but in those cases where the deformation is symmetrical this is probably a faithful reproduction of the flow, at any rate on sections parallel to the axis of the section.

It should, perhaps, be pointed out that such experiments with a fluid cannot reflect any aspect of deformation which is due to the vectorial, crystalline properties of the metal. For example, Taylor and Quinney have shown, and this has been confirmed by Siebel, that when an unworked rod is drawn through a die the shear occurs almost entirely in the first pass and thereafter remains essentially unchanged. As a result the shape of the wave front after the first pass does not coincide with that due to subsequent passes of the already cold-drawn material. It is clear that the behaviour of the latter cannot be exactly duplicated by the flow of a fluid ; all that the latter can do is to provide a picture of the deformation of the original, isotropic metal.

Discussion.

Dr. C. H. Desch said that the references to previous literature did not include a valuable paper published in the "Proceedings" of the Royal Society of Edinburgh, long before the war, by Gulliver, dealing with the application of the Hele-Shaw method to the examination of the flow in test pieces. Gulliver had applied quantitative calculation, as had the authors of the present paper, to determine what should be the plane of fracture and had found a very good correspondence with the actual result. He had also investigated the effect of notches, both sharp and rounded, at various angles, and the Hele-Shaw lines had again corresponded very closely with the actual deformation and fracture in the test pieces.

Dealing with the question as to how close was the analogy between the flow of a viscous liquid and of a plastic solid during deformation, he said the authors had shown that the analogy was close over a certain range, but there must be differences, because of the enormous difference of viscosity between even the most viscous liquid and a solid. For example, it was pointed out that one never obtained turbulent flow in a plastic solid, whereas turbulence was easily obtained in even a viscous liquid. The authors had, wisely, tested whether push and pull were equivalent, and had found that they were, within the range examined ; but it could not hold over the whole range. If one streamlined the die in an extrusion press the metal would not go through at all, but would jam ; there must be a sharp right angle, and then the metal would flow. But the flow was not then streamline flow, and the question arose as to the stage of deformation at which the difference occurred between streamline flow through a wire-drawing die and the non-streamline flow through an extrusion die. There must be a critical point.

Mr. T. H. Turner, discussing the applicability of the authors' method to hot and cold working, said that a cold mild steel did not commence to flow in the manner indicated in the paper ; there was a wedge of deformation in a different direction from that of the flow lines shown in the paper. Therefore there must be some change in the mild steel which would eventually give a picture corresponding to those in the paper. From Luders' lines we knew that the beginning of the flow in mild steel was definitely different from that depicted in the paper.

Dr. E. W. Fell suggested that the lines obtained in the macrostructures of any general type of forging were not flow lines, though he believed they provided some sort of qualitative indication of flow.

It seemed that consideration would have to be given to the fact that in the Hele-Shaw apparatus the shape of the walls of the channel was entirely different from the shape of the walls during tube or wire drawing, where the walls were the surface of contact of the metal as it passed through the die. The shape was quite different in the two cases. Drop forging was merely a case of a general forging, although the forging operation took place at a quicker rate, and he believed the disposition of the metal in drop forging could be controlled to a greater extent. But the operation was the same, in that it could be divided into a number of stages of deformation, and the lines in the macrostructures would not be true flow lines.

Mr. J. D. Hannah, referring to the difference between pressure and suction, in applying suction, presumably, the authors had simply to remove the atmospheric pressure from beneath the liquid, wnilst leaving it applied at the top, and he asked if that differed fundamentally from applying pressure greater than atmospheric above the liquid. It did not seem probable that the liquid could in fact sustain tension.

Dr. W. H. Hatfield suggested that some speakers were inclined to credit the authors with having read too much into the experiments. He pointed to one case in the paper where the analogy between the flow through a contour and the drop forging was very complete, and said the method did lend itself very well, indeed, to the determination of much comparative and empirical data which would be very helpful and instructive, always bearing in mind that there were two dimensions and not three. He congratulated the authors on a very useful contribution. If they were working in three dimensions instead of two and with materials of the viscosity of heated steel the results would be in no sense comparable. The authors had visualised for the purpose of the debate that the inclusions were fixed, immovable bodies of certain intrinsic characteristics which remained constant ; but when one considered the inclusions in glasses and the inclusions in steel it was a fair inference that when the steel was heated and became plastic the characteristics of the slag inclusions were modified. At any rate, the slag inclusions were so considerable in number and so small in dimensions that he questioned whether the analogy was not far too much overdrawn, and in a sense somewhat mischievous.

Dr. A. McCance, dealing with the question as to whether there was a real analogy between flow lines and the facts revealed by etching a drop forging, suggested that it had been overlooked that while the material was flowing it had reached a steady state, so that aspects of flow did not enter into the matter. He referred to a picture in the paper where the tangent at any particular point had remained constant. Consequently, he said, the picture was really indicating displacement, and to that extent it was exactly analogous to any movement that had taken place, or any lateral displacement, in a bar with longitudinal lines in it. One was measuring only displacement under steady flow.

Professor Thompson, replying, expressed his indebtedness to Dr. Desch for the reference to the paper by Gulliver, of which he had been unaware.

Dealing with the influence of viscosity, he said he believed that, provided there was a streamline flow, the viscosity factor was quite unimportant. At any rate, that seemed to be the view adopted by the hydrodynamic experts whom he had consulted.

In the early days Mr. Herbert and himself had carried out some experiments on extrusion, and the results explained exactly why, for satisfactory extrusion, one must have a sharp-angled and not a streamlined die. At the sharp right angle the streamlines were pressed very closely together, an indication that the pressure on the metal at that point was extremely high ; as a result deformation and the flow of the material occurred relatively easily. On the other hand, when using a streamlined die, the streamlines were relatively far apart, indicating a relatively low pressure. It was not surprising, therefore, that the sharp angle was required. He had discussed the point with Dr. H. W. Brownsdon, from whose very large experience it seemed that one could get reasonable concordance between the results of practice and the results that could be deduced from the Hele-Shaw apparatus experiments.

Replying to Mr. Turner, he agreed that the authors had not so far been able to duplicate anything like the cone or pyramid that occurred at the commencement of flow in a metal. On the other hand, if one used the quasi-quantitative method which they had applied in the case of wire, one would get something rather close to it, and he was not at all sure that further work would not make it possible to obtain at any rate some sort of rough approximation, although he agreed that one would not obtain in that case complete quantitative agreement.

It seemed that Dr. Fell regarded the matter rather more fundamentally than perhaps the method justified. If one considered atomic displacements, one reached a state of affairs which, of course, one could not even approximately duplicate. On the other hand, it seemed rather difficult not to believe that the position taken by the inclusions after a certain deformation had been applied to the metal was the position to which the inclusions, and therefore presumably the metal around the inclusions, had flowed. However, the authors made no dogmatic claims for the method yet ; they did not known any too much about it themselves.

Replying to Mr. Hannah, he said the suction experiments were carried out simply because otherwise the authors might have been challenged on their wire-drawing work, on the ground that in the Hele-Shaw method the glycerine was pushed through from above and not drawn through ; if they could obtain the same results whether they pushed the glycerine through from above or sucked it through from below, they could eliminate one possible source of criticism. But he agreed with Mr. Hannah's remarks concerning the difficulty of sustaining liquids in tension.

In the paper the problem of inclusions was dealt with from one point of view only, *i.e.*, their effect on wire rod, and he believed that, without question, all drawers of wire would agree that inclusions were bad —probably adjectively bad. Many of the inclusions were probably in part glassy, as Dr. Hatfield had suggested, but one of the most important and objectionable of all the inclusions—alumina—was definitely crystalline, so far as one could see. However, that did not affect very much the authors' argument.

They had not attempted yet to go into details such as the effect on the flow of the presence of two constituents of widely different properties ; they had dealt with a single material, and he was doubtful whether the method lent itself to anything more than that. There were lots of questions of the type raised by Dr. Hatfield which he was afraid the authors' particular apparatus could not answer.

In no case had they obtained more striking confirmation of the agreement of the flow obtained in the apparatus with the flow actually occurring than in connection with tube drawing, and he described the experiment to emphasise how very close the agreement was.

Mr. Herbert, who also replied briefly, agreed with Dr. Desch that the range through which the analogy held was an important matter. With regard to Dr. Fell's suggestion that the lines in the metal were not really flow lines and that there was a series of small movements, Mr. Herbert said that if one integrated all the small movements one obtained practically a flow line, or at any rate, a line comparable with the authors' flow line.

A "Report on Waste-heat Boilers in Open-hearth Practice" was then presented by the Open-hearth Committee.

WASTE-HEAT BOILERS IN OPEN-HEARTH PRACTICE.

It has generally acted as a controlling Committee for various Sub-Committees engaged on the investigation of different problems, but has also carried out other investigations directly. In October, 1932, the Committee decided to initiate investigations into the economic value of the waste-heat boiler regarded as a steam-generating and fuel-saving adjunct to the open-hearth furnace. Statements made at the Fifth Open-Hearth Conference, held on October 21st, 1932, had revealed divergence of opinion as to the value of these boilers, although the greater number of those open-hearth managers who were operating their furnaces with waste-heat boilers expressed the opinion that the results obtained from the boilers justified their installation. The research on this subject was carried out by the Technical Department of the British Iron and Steel Federation acting for the main Committee ; this procedure was adopted in preference to directing the work through a sub-committee, since the problems considered were chiefly of an engineering nature.

Preliminary investigations revealed that while many papers and articles have been published on the subject of the installation of waste-heat boilers in conjunction with open-hearth furnaces, most of these are general in character and give little reliable data. It was decided, therefore, that a carefully prepared and accurately recorded trial should be carried out on a waste-heat boiler, preferably at a works where conditions of operation are typical of those usual in Britain—that is, where comparatively small fixed furnaces are fired with hot producer gas from a central battery of gas machines. The co-operation of the Park Gate Iron and Steel Company was readily forthcoming, and the greater part of the preparation for the trial devolved upon the technical officers and staff of that company, as well as the bulk of the actual recording of data during the week's duration of the trial. The results of this trial are set out in the Report, with a full description of the methods of measurement employed ; it is believed that no waste-heat boiler trial records of the same complete nature have hitherto been published.

The Committee has also considered the economic factors governing the profitable installation of waste-heat boilers. In the Report a method of calculating the net saving due to the steam production is set out, which is recommended by the Committee for this purpose ; the benefits due to improved furnace operation as a result of greater draught being available are recognised as being important, but are calculable only for individual instances ; in some cases existing chimney height is adequate, whereas in others a new furnace chimney of suitable proportions would provide the improved draught at less expense than a waste-heat boiler. It is also recognised that comparatively slight reductions in the volume of hot waste gases supplied to the boiler may seriously affect its economic value, and that it is possible that boilers installed under conditions which resulted in a satisfactory return on capital may show inadequate return after such a change in the quantity of heat supplied.

The Committee, while recognising the importance of the engineering aspects of waste-heat boiler practice, decided that these aspects do not properly lie within the scope of a Committee dealing with open-hearth practice. These matters, therefore, are dealt with in a contribution by Mr. A. F. Webber, which incorporates notes on installation and operation, as well as a method of waste-heat boiler design which will enable those

considering a waste-heat boiler installation to estimate probable dimensions and outputs with reasonable accuracy.

The Report ends with a bibliography.

Discussion.

Mr. James Henderson, who was Chairman of the Iron and Steel Industrial Research Council at the time the work was inaugurated, said that the Report provided a very admirable example of the method of investigation and research that had been developed under the direction of Sir William Larke, Mr. E. C. Evans, and other officers of the Federation. If it were suggested that by proper design of the open-hearth furnaces there would be no necessity for waste-heat boilers, the suggestion must be answered by the designers of the furnaces. But the fact remained that practically all the successful furnaces left a large amount of heat which would otherwise go to waste at the stack, and the introduction of waste-heat boilers had resulted in very definite and substantial economies and increased efficiency.

Mr. P. S. G. Kirke—Cochran and Co. (Annan), Ltd.—said that the boiler described was admittedly too large for the 50-ton furnace, and the dampers at the outlet of the fan had to be partly closed, because it was impossible to vary the speed of the fan motor. Therefore, the conclusions arrived at were not really quite fair to waste-heat boiler practice. Referring to a waste-heat boiler recently started up on a 50-ton furnace in a South Wales steel works, he said it had slightly sinuous tubes, its diameter was 8¼ft. instead of 9ft., there were only 9ft., instead of 18ft., between the tube plates, but it was evaporating 5250 lb. of water per hour and turning out superheated steam. Instead of taking 23 kW to drive the fan, it was taking only 12½, and the heating surface on the gas side was only 1400 square feet. Curiously enough, there was another fire-tube boiler on a 50-ton furnace adjacent to it, having long, straight tubes and evaporating about the same amount of water, but the fan power was rather more than double.

In cases where hot gases were taken direct from the producer and not preheated, the temperature of the waste gases available for the boiler would be higher than the 455 deg. Cent. mentioned in the Report, and under those conditions, of course, the value of the waste-heat boiler to the steel works became greater. It was on record that over 4 lb. of steam from and at 212 deg. Fah. had been obtained per lb. of coal fed into producers, which was approaching double the figure given in the Report; the Report dealt with a case in which the gas was regenerated as well as the air.

The figure of 4·4 kW for the fan per 1000 lb. of steam from and at 212 deg. Fah. per hour was high, and by correct design of the boiler it could be reduced to 2 kW, or, say, 3 b.h.p., per 1000 lb. of steam from and at 212 deg. Fah. Allowing 25 lb. of steam from and at 212 deg. Fah. per b.h.p., the power required by the fan was thus reduced to 7½ per cent. of the output of the boiler, and a good deal of the 7½ per cent. could be recovered by the addition of an exhaust steam feed heater, provided the feed water was not too hot to make that unjustifiable. An alternative method to electric fan driving was the use of a compound steam engine, which would take very little steam; the geared turbine was even better mechanically, but less efficient, requiring more steam. By these methods one saved the capital cost of electrical generating plant, and was not affected by a breakdown which might occur in the latter.

The capital cost of £2280 for a waste-heat boiler for a 50-ton furnace was about 50 per cent. higher than the figures relating to present practice. Further, considering the boiler in South Wales to which he had referred, and assuming that in the fuel-fired boiler one could make 7 lb. of superheated steam per lb. of coal, and that the coal cost 12s. 6d. per ton, 5250 lb. of steam per hour saved 750 lb. of coal per hour, which was 50 tons per 150-hour week, valued at £30. So that the fuel saving in a year became £1600, which was very nearly the capital cost of the boiler. It seemed to be suggested in the Report that in order to provide for auxiliary firing by blast-furnace gas or producer gas, it was necessary to use a water-tube boiler. That was not so, however; a fire-tube waste-heat boiler, if designed for it, made a magnificent boiler for firing with blast-furnace gas alone, and it was easy to arrange to fire such a boiler with blast-furnace gas during the week-end, when the furnaces were shut down. Mr. Kirke did not agree with the suggestion in the Report that for a very large furnace one might put in a water-tube boiler. It was quite possible, he said, to supply a single-drum, fire-tube waste-heat boiler to operate in conjunction with a 250-ton steel furnace; such a boiler would be very much cheaper than a water-tube boiler, and would not be open to the latter's objections. He had seen a good many waste-heat boilers in operation in steel works with a draught drop through the tubes of 4in. of water. In the boiler referred to in the Report the draught drop was 1in., which was very little, and was due to the boiler being too big. But 4in. was too great; there was a tendency to reduce the cost of the boiler by reducing flue area, but he considered it a retrograde step, because it meant increasing considerably the power required to drive the fan.

Commenting on the suggestion that waste-heat boilers might not be justified when rolling mills were driven electrically, Mr. Kirke said the capital cost of generating electricity would be less with waste-heat boilers and turbo-generators than with blast-furnace gas engines.

Mr. W. J. Brooke (Normanby) said that at Normanby Park the amount of blast-furnace gas and coke-oven gas going into the furnace could be measured accurately, and the actual amount of air going past the valves from the fans was also measured. From these observations a good deal of useful data was obtained. Discussing the value of a boiler, having regard to the varying efficiency of open-hearth furnaces as between the beginning and end of their careers, he gave some figures relating to a furnace which was approaching the end of its useful life, and which was working very inefficiently. A considerable amount of the lack of efficiency was taken up by means of a waste-heat boiler, and there was an extraordinary increase of the amount of steam available under those conditions. So that, whilst he did not advocate that a furnace should be kept on too long after it began to show loss of efficiency, he urged that at any rate some of the lost efficiency could be regained. For example, one furnace, in comparatively good condition, was making 5·1 tons of steel per hour, as against 4 tons per hour for the Park Gate furnace dealt with in the paper. The steam produced was 5090 lb. per hour, as against 3208 lb. at Park Gate, and the boiler efficiency was 40·5 per cent. On the other hand, a furnace at Normanby Park was working very inefficiently, making 4·2 tons of steel per hour, and using a large amount of gas; the number of therms entering the boiler was about 203 per hour, as against 115 per hour at Park Gate. But the steam produced was 8400 lb. per hour, equivalent to 2000 lb. of steam per ton of steel produced, as compared with 800 lb. of steam per ton of steel at Park Gate.

Remarking that some works had to operate at higher intensity than others, Mr. Brooke gave some figures covering a whole week at Normanby, where the average output was 5·8 tons per hour on a 140-hour week. The average steam production per ton of steel over the whole shop with seven furnaces was 1740 lb. That included the mixers. The heat consumption per ton of steel, not allowing for the steam, was just over 6000 units, which figure was high. On the other hand, a high production type of steel, of very low carbon content, and some high-silicon steel were made. The heat consumption per ton of steel was about 4½ million units, as against a little over 3½ million units at Park Gate. But at Normanby the production was 5·8 tons per hour, as compared with 4 tons per hour at Park Gate, and one might consider whether it would not be worth while operating under high-intensity conditions, which might result in higher heat consumption, but would enable the plant to work at greater output.

Mr. J. W. Reber, referring to a figure of 13·30 therms per hour given in the summary of results as radiation and convection losses, said that it represented 27 per cent. on the heat available for the boiler, which was unusually high for ordinary waste-heat boiler practice. It was rarely more than 5 per cent. Observing that a steam output of 821 lb. per ton of steel was rather on the low side, he pointed out that high steam yield from a waste-heat boiler did not always mean economical furnace operation. If the gas exit temperature was below 450 deg., the economic value of waste heat recovery became very doubtful. By eliminating as much as possible air infiltration and heat radiation losses at the regenerators, it should be possible to increase the temperature to 550 deg. at least, with resulting increase of evaporation which would justify the installation of waste-heat boilers.

Dealing with the point that tubular boilers required four or five times as much draught as water-tube boilers, he said that in practice the exit temperature from a water-tube boiler was very much higher than from a tubular boiler. For the case at Park Gate, the installation of a water-tube waste-heat boiler would not have been an economical proposition. A water-tube boiler, to give good waste heat recovery, would use as much back pressure as a tubular boiler. The formula in the Report gave rather shorter tube lengths than were necessary for actual practice.

In designing waste-heat boilers for open-hearth furnaces, a generous allowance should be made for overload conditions; in many cases waste-heat boilers had been given a bad name because the reserve of fan power was insufficient.

Mr. E. C. Evans (British Iron and Steel Federation), dealing with the statement that there were considerable discrepancies between the external cooling losses as measured at the boiler and those which could be calculated by fundamental formulæ from the surface temperature of the boiler, said he was not prepared to accept that the discrepancies were due to experimental error, having regard to the care with which the experiments were conducted. The problem of determining external cooling losses had arisen on previous occasions. A long investigation on the external cooling losses on large furnaces was reported to the Institute by Mr. D. F. Marshall, and the convection and radiation losses were far lower than was thought would be the case. Fundamental formulæ had to be accepted as being correct, and he was prepared to say that the results in the waste-heat boilers Report were correct within the limits of experimental error. He urged the need for an experimental exploration of the possibility of determining accurately the external cooling losses in large industrial structures, such as those employed in iron and steel practice.

Mr. T. P. Colclough emphasised a point made previously by the President that the waste-heat boiler must be a servant and not a master in open-hearth furnace practice, and that the fundamental need was to design the furnace on efficient lines to give the heat where it was required, *i.e.*, in the bath and not in the form of steam. The excellent report presented would serve as a text-book for many years. The fundamental difference between the figures presented by Mr. Brooke and those given in the Report lay, not in the furnace or in the boiler as such, but in the connections between the furnace and the boiler. The decision as to whether or not to install a waste-heat boiler depended on whether the temperature of the waste gases was higher or lower than that of the incoming fuel gas supply. The data in the Report showed that the waste gases going to the boiler had a temperature lower than that of the producer gas going to the furnace, which seemed to indicate excellent design and construction of the furnace. But examination of the other figures showed that it was the result, not of good design, but rather of bad construction. The average CO_2 content of the waste gases going to the boiler was only 8 per cent., and the waste heat temperature was in the neighbourhood of 480 deg. Cent. The mere fact that the CO_2 content of the gas was down to 8 per cent., instead of 16 or 18 per cent., gave the reason why the temperature was low and why the waste-heat boiler was not raising as much steam as it should. The volume of waste gases dealt with by the boiler was enormously larger than it ought to be, and the temperature of the gases going into the waste-heat boiler, instead of being about 480 deg. Cent., ought to be in the neighbourhood of 700 deg. or 800 deg. Cent., in view of the design of the regenerator and furnace. In that case the waste heat steam generation would come very closely into line with the figures given by Mr. Brooke.

Mr. A. F. Webber, replying to the discussion, said there were two pages in the Report devoted to the problem as to whether an efficient furnace would leave any waste heat for the boiler to use, and reasons were given for believing that the more efficient the regenerative system the more "surplus" heat there would be. Clearly, efficiency meant reduction of "waste heat." It might well mean increase of "surplus heat." If there were a really efficient regenerative system on the furnace, one would not need to take so much heat out of the furnace gases to give the required degree of pre-heat to the incoming gas and air, and there would be more available for the boiler than was the case where there were heavy heat losses in the regenerator.

Too much had been made of the fact that the Park Gate test was not representative. The conclusions of the Report, the methods of design, the methods of estimating the economic result, did not depend directly on the actual results at Park Gate. Those results served as a check on certain methods of doing it; that gave confidence in those methods, and one could apply them to more generally representative data.

The boiler in South Wales, referred to by Mr. Kirke, was not in operation at the time the Report was prepared, but Mr. Webber said that he had seen it working since, and was greatly impressed by it, and he hoped it would be possible to give further details of it later. It would appear to have marked advantages over the longer straight tube type. He did not agree with Mr. Kirke, however, as to the advantages of steam drive over electrical drive; the conditions in gasworks, where steam drive was widely employed, were very different from those of steel works. Electricity was much cheaper as a rule, and one could not utilise the exhaust steam from the driving unit. Nor did he agree with the method of calculating results by finding out the equivalent evaporation of a fuel-fired boiler. Such calculations always showed that the waste-heat boiler would pay for itself in eighteen months or two years! But in the Report reasons were given for thinking that the method of actually determining the steam costs on the waste-heat boiler and on the alternative plant was the proper method.

Possibly there were cases in which the radiation and convection losses were as little as 5 per cent. of the available heat, as indicated by Mr. Reber; if so, the waste-heat boiler, as a boiler, was far more efficient in minimising radiation and convection losses than was any other type of boiler. Perhaps an explanation of the discrepancies between various figures was to be found by reference to the point at which the heat supply was measured. In the Park Gate tests it was measured at roughly the point at which it became available from the flue. In order to get it to the boiler one had usually to adopt fairly extensive gas-ducting systems, which meant heavy heat losses. The boilermaker, however, did not like to consider those as heat losses; he considered as available heat the actual heat at the boiler. The discrepancy in regard to radiation and convection losses might be due partly to the rating of the boiler at Park Gate.

The statement in the Report with regard to draught loss meant that the draught loss on waste-heat boilers of any type were four or five times as much as in normal fuel-fired boilers.

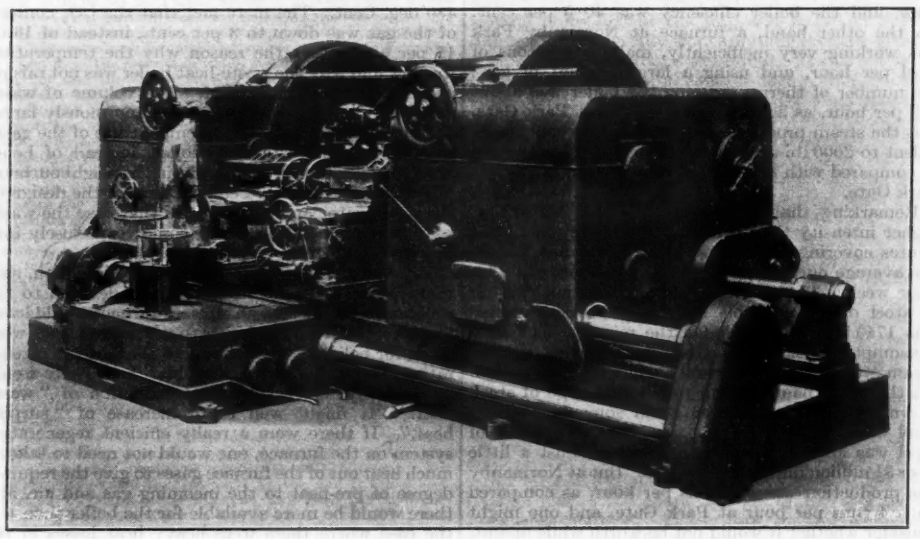
Discussing the suggestion that the CO_2 content of

the waste gases should be 16 or 18 per cent., Mr. Webber said that after discussing the matter with experts his general impression was that if one were able to preserve the regenerator system from all air infiltration, it would all melt within a short time. The uptakes, particularly from the regenerators, depended on a certain amount of radiation and convection losses on the one hand, and a fairly extensive air infiltration on the other hand, to cool them and preserve them for an adequate life.

It was intimated that the Report would be submitted for discussion in various industrial centres throughout the country.

78in. Railway Wheel Lathe.

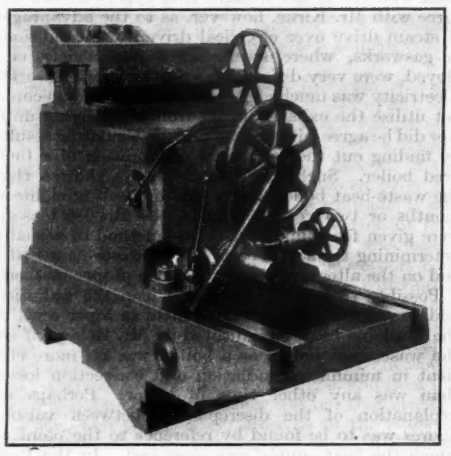
There has recently been completed by Noble and Lund, of Felling-on-Tyne, the first machine of a new range of wheel lathes which they are putting on the market, and which will be sold by Alfred Herbert, Ltd., of Coventry. The machine, illustrated herewith, is designed for the rapid turning of new or worn railway wheels when mounted on their axles. The rigidity of its design, together with the provision of a wide range of spindle speeds, is claimed to make it suitable for the use of high-speed cutting alloys up to their limit.



78-Inch Railway Wheel Lathe

The bed is a casting closely ribbed internally and is formed with broad bearing surfaces to take the headstocks and slides. In the centre of the bed large chutes are provided for carrying the turnings to a pit in the foundation. All the headstock gears are enclosed in two heads, in which each gear shaft has at least two rigid bearings. Each head is mounted on three machined ways on the bed. The pinion shafts, of high carbon steel, have solid forged pinions. Each shaft is carried in three gun-metal capped bearings arranged so that two of the bearings are one on either side and close to the pinion.

The position of the left-hand headstock is determined by means of a narrow way with an adjusting strip, and lifting is prevented by strips bolted to the underside. The right-hand headstock is adjustable along the bed by a quick power motion driven by a reversing motor mounted at the rear. This motor drives through friction clutches, the control of which is brought to the front close to the operator's hand. The motion is transmitted by a revolving nut on a large diameter steel stationary screw, which is placed over the centre of the narrow guides and well above the bed. The headstock is locked to the bed by two wedges. A variable-speed motor driving a two-speed gear-box provides the requisite range of spindle speeds for tire turning. Alternatively, a six-speed box and constant-speed motor can be fitted.



Tool Slide

The main spindles are of chilled cast iron and revolve in bearings fitted with renewable half bushes with caps. The thrust is taken by ball races. To receive axles with outside journals or for carrying lathe centres for dealing with inside journal axles, steel sleeves having tapered bases are fitted inside the main spindles. They are adjustable in or out by hand wheels reached from the operating platform. The face plates are of box section with tee slots to take drivers and recesses to accommodate outside crank pins. Automatic lubrication is provided for the whole of the driving mechanism. A central tank supplies filtered oil to reservoirs in the two headstocks and gear-box. The oil feeds each bearing and cascades over the gears.

The tool slides are of cast steel, and are mounted on intermediate slides which can be set to an angle of 1 to 20 to suit the treads of wheels, or can be set square for tire boring. The intermediate slides are mounted on pillar rests which are adjustable on base plates for in-cutting feed and for setting to suit the size of wheels being turned.

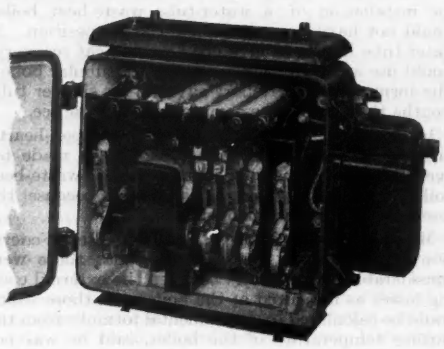
The design of tool rest adopted is claimed to obviate the necessity of slacking off and retightening a number of bolts when changing over from one size of wheel to another. Further, the cut is always parallel to the face plate whether the tool slide is set square or at an angle. A direct-reading scale can be used for ascertaining the diameter of the wheels being turned.

Four independently variable and reversible feeds are provided for the tool slides, in addition to a quick-power motion controlled by a "joy-stick." The operator moves the joy-stick in the direction in which he wishes the slide to move and the quick-power traverse comes into action.

The maximum diameter of wheels which can be turned over the tread is 78in. and the minimum 36in. The gauge of wheels admitted is 5ft. 6in., and the diameter of the face plates is 80in. The machine has a weight of about 61½ tons, and is driven by a main motor of 50 h.p. The same design is made in sizes to suit wheels of 54in., 66in., and 90in. diameter.

D.C. Timing Motor Starters.

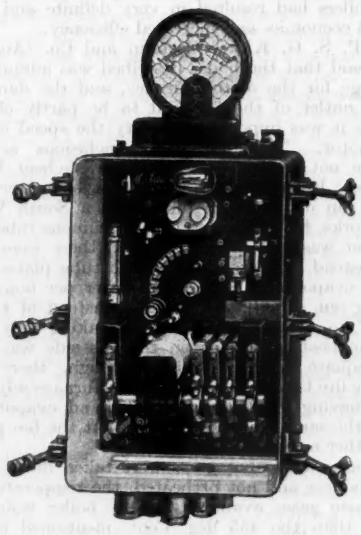
New D.C. marine type timing starters for industrial use have been introduced by the General Electric Company, Ltd., of Magnet House, Kingsway, to meet the increasing demand for automatic motor starting equipment. One of the main advantages of these starters is that the motor is accelerated at a uniform rate, irrespective of the load, a feature of considerable importance in the case of reciprocating machinery, as it prevents rapid acceleration accompanied by undue cutting out of the starting resistance on a light load, which may be followed by a peak load. Another advantage of these equipments is that no damage is done to the starter or resistance in the event of mechanical trouble, such as a seized motor bearing or a jammed fan rotor, as the starter cuts out the resistance progressively until tripped by the overload relay.



Constant Speed Timing Starter

The starters are supplied for motors up to 20 h.p. at 400–500 volts and in standard types for constant or variable speed motors. A simplified starter is also made for small constant-speed motors, and both types can be arranged for remote control from push buttons, float switches, and pressure switches.

In the standard form the starter incorporates a magnetically operated clock mechanism, by means of which a series of finger contacts is made to close in quick succession and in the correct sequence, thereby cutting out the starting resistance at a predetermined rate, the number of resistance steps being dependent upon the horse-power. The clock gear, which is devoid of springs, is composed of rust-proof material and is enclosed in a case. In the larger sizes it is adjustable. The finger contacts close with a combined rolling and wiping action, and where there is a possibility of arcing arc chutes and powerful magnetic blow-outs are provided. For motors above 10 h.p. the starter contacts are short circuited by a line contactor when the starting operation is completed. At the top of the starter there are "stop" and "start" push buttons and a pilot lamp holder. Terminals for a remote pilot lamp and remote control are also provided. Overload trips of the adjustable time-limit type arranged for hand resetting and a no-volt release provide protection. When required, the starter and motor can be isolated from the supply by a main isolating switch mounted on the outside of the case. The complete assembly, including starting resistance at the back of the panel, is housed in a water-tight welded steel case with a removable cover. When a shunt regulator is fitted for speed variation a full field interlock is provided.



Variable Speed Timing Starter

The simplified form of starter, shown in the first illustration, comprises a timing element of similar design with a sufficient number of resistance steps to ensure smooth acceleration of the motor and having the resistance mounted on the panel immediately above it. The complete unit is enclosed in a ventilated weather-proof cast iron case with a drip-proof canopy and a hinged cover. When the starter mechanism, which has a strong magnetic blow-out for each pole, is in the open position the motor is completely isolated from the supply. If required, a time limit overload relay of the hand resetting type can be fitted on the side of the starter.

Automatic Cold Sawing Machine.

The latest design of automatic cold sawing machine made by S. Russell and Sons, Ltd., of Leicester, is illustrated herewith. Two machines of this type have recently been supplied to the British Thomson-Houston Company Ltd. for the Willesden and Rugby Works. The principal feature of the machine is the provision of hydraulic power for feeding the saw and for clamping and feeding the material to be sawn. An important development in connection with the arrangements for feeding the material to length is incorporated in the design.

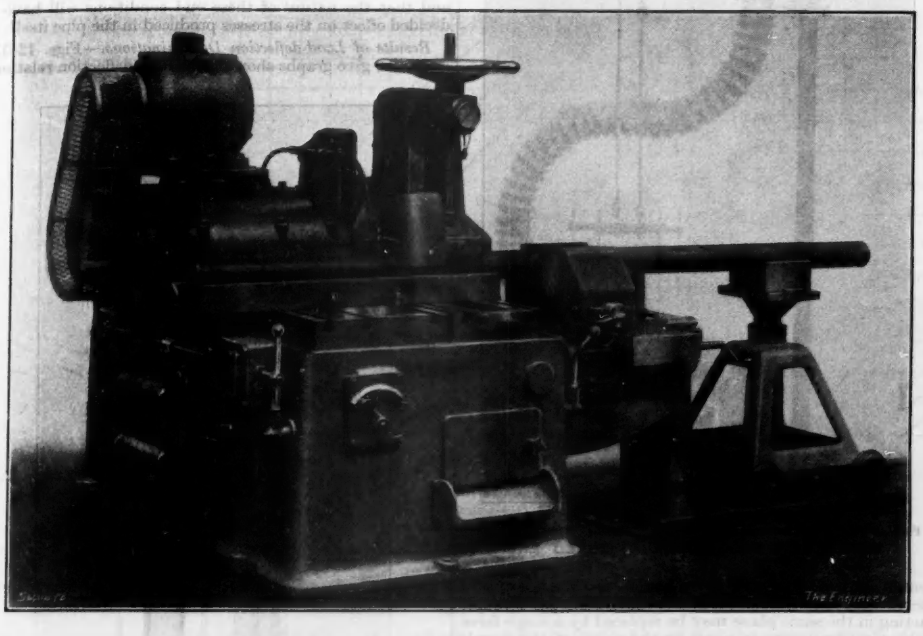
The bed, a monobloc casting, carries the saw saddle on wide slides and is formed with T-slotted work tables, a chip compartment and a coolant tank. From the main motor mounted on top of the saw slide the saw spindle is driven by chain or vee belting through four-speed reduction gearing running in an oil bath. For saws from 20in. to 24in. in diameter the main motor is of 7½ h.p., while for saws from 26in. to 30in. in diameter the motor is of 10 h.p. In all cases the preferred speed of the motor is 1000 r.p.m.

The pumping equipment for the hydraulic movements is housed in the main bed and is driven by a separate 2 h.p. motor. It consists of two pumps, a variable-stroke pump delivering a regulated supply for feeding the saw into the work and a constant delivery pump supplying the cylinders of the material feeding and clamping gear and also the quick return motion of the saw saddle. The arrangement of the hydraulic saddle feed is such that the rate of feed is not affected by change of temperature. Further if the resistance to the feed exceeds a certain limit oil is returned to the supply tank through a pressure relief valve.

Under automatic action two jaws are closed by hydraulic pressure and grip the material. The carriage on which these jaws are mounted then moves forward a predetermined distance towards the saw. At the end of this motion the vertical vice comes automatically into action and clamps the material firmly while the saw saddle advances and cuts off the given length. During this period the feed jaws open and the jaw carriage returns to its original position ready for another cycle. On the

completion of the cut the saw saddle automatically withdraws and the vice opens.

In all sizes of the machine the maximum length which can be cut off under these automatic conditions is 0½in. In earlier designs Messrs. Russell adopted the usual practice of feeding the material up against a fixed stop on the table. This arrangement is however held to have certain disadvantages particularly when material such as stacked flat strip is being cut. In the improved design illustrated measurement is carried out on the knee bracket carrying the feeding mechanism. The measurement required is

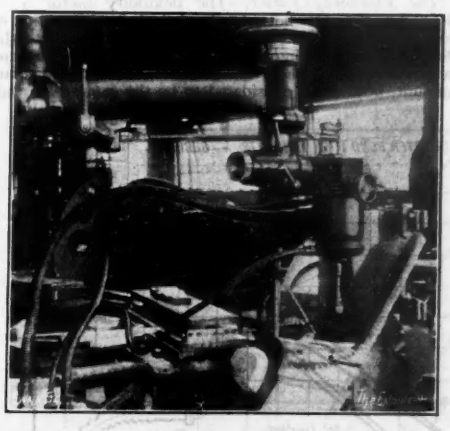


AUTOMATIC COLD SAWING MACHINE

set on a scale on this bracket. Thereafter the movement of one lever brings the automatic action of the machine into operation and results in equal lengths being cut off the material until it is exhausted.

New Hydraulic Diesinking Attachment.

WITH the object of providing a convenient method of producing dies and moulds on standard milling, drilling, or boring machines, the Clearing Duplicator Corporation, of Chicago, Illinois, U.S.A., has introduced a hydraulic copying attachment, which has many of the advantages of the fully automatic electro-mechanical die-sinking machine. The agent for the attachment in this country is George H. Alexander Machinery, Ltd., of Birmingham. An illustration of the duplicator in position on a Cincinnati vertical milling machine is shown herewith. The essential principle of the attachment is the hydraulic control of the vertical movement of the knee of the machine by means of two hydraulic cylinders under the influence of a piston valve and stylus in contact with the pattern to be copied.



HYDRAULIC DIESINKING ATTACHMENT

For this purpose the base casting of the machine is machined to take one cylinder on each side of the knee, and the standard nut for the elevating screw is removed and replaced by a sleeve nut which is capable of sliding vertically under hydraulic control, or which may be used in conjunction with the normal elevating screw for hand control or feed movements. To complete the attachment the piston valve and stylus holder are carried on an arm bolted to the column of the machine, and supplied with oil under pressure from a pump and motor. Relief valves and a needle control valve are fitted in the hydraulic system to prevent undue pressure being built up and to regulate the speed at which the table is raised or lowered. When the knee is in the lower position and the stylus is out of contact with the pattern to be copied, oil is supplied under pressure to the hydraulic cylinders to raise the knee until contact is established between the stylus and one edge of the pattern. This action results in a slight lift of the piston valve, with the result that the flow of oil is by-passed back to the reservoir, although sufficient pressure is maintained in the cylinders to hold the table in the raised position. The die block is, of course, so mounted that the cutter is clear of one edge of the blank when the stylus makes contact with the pattern, or, if desired, with a platform built round the edge of the pattern. The longitudinal feed to the table is then engaged, so that the stylus traverses the face of the pattern, and the cutter is fed into the work.

It should be mentioned that in addition to the direct vertical lift of the piston valve by the stylus, the latter is mounted in a ball joint, and the upper end of the stylus holder engages a conical seating in the piston, so that $\frac{1}{32}$in. lateral movement of the stylus is sufficient to raise the piston valve and by-pass the oil. Thus, if the stylus encounters a projection or a raised portion of the pattern during the longitudinal travel, oil is by-passed to an extent that allows the knee of the machine to fall under its own weight until the stylus returns to a central position. Conversely, should the travel of the stylus across the pattern bring the point over a cavity or depression, the closing of the valve cuts off the by-pass action and oil is supplied to the cylinders to raise the knee until contact is re-established. In this way the entire profile of the pattern is reproduced without attention on the part of the operator. When the other side of the pattern is reached the hand control of the hydraulic motion enables the table to be rapidly lowered until the work clears the cutter. The table is then returned to the initial position, a slight cross feed is applied, and another longitudinal traverse is made, and so on, until the entire surface of the pattern has been covered.

When using this attachment, both the depth of cut and the feed may be set to the maximum of which the machine is capable, and sensitive adjustments are provided to compensate for the weight of the piston valve and the point of cut-off. The pressure between the stylus and the pattern is comparatively slight, and either plaster or wooden patterns can be utilised, although it is recommended that for the best work a hard wood pattern, well varnished, should be used.

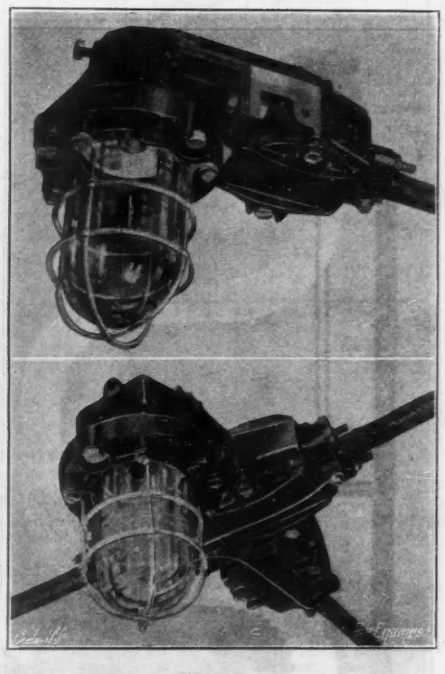
It is claimed that tests have shown that the accuracy of work produced with this attachment is fully equal to that from the best automatic die sinkers, whilst the operation times are approximately the same. The addition of the attachment does not impair the normal functions of the machine.

Flame-proof Electric Lighting Equipment.

CABLE end couplings and lanterns forming self-contained units have been introduced by George Ellison, Ltd., of Perry Barr, Birmingham, 20, for electric lighting in places in which the atmosphere may become charged with an inflammable or explosive mixture. They have passed the stringent tests applied by the Mines Department testing station at Buxton in methane, acetone, and petroleum vapour, and may be used for roadway lighting within the limits permitted under the Coal Mines General Lighting Regulations, 1934. The cable end couplings embody the advantages of the Ellison end couplings for power supply and are made under the same patent. They will accommodate two or three-core single-wire armoured cables up to size 7/·044 and with a maximum diameter under the armour of ⅝in.

Although the Coal Mines Regulations mentioned limit lighting circuits to 10 ampères at not more than 125 volts, these fittings are suitable for 15 ampères at 230 volts. Each cable end coupling has three terminals, permitting the use of three-core cable for any form of distribution using three wires. When two-wire distribution is adopted it is sometimes desirable to use a third wire to permit the circuit to feed from one pole at one end and the other pole at the opposite end. This circuit, which was described in a paper on "Underground Lighting and Trailing Cables," before the West of Scotland Branch of the Association of Mining Electrical Engineers, by Mr. J. A. B. Horsley, is intended to keep the voltage at the lamp terminals more constant than it would be if the same circuit were fed from both poles at one end only.

The Ellison cable end couplings are suitable for this type of circuit, and as with the firm's larger cable end couplings, the ends of the cables may be connected and sealed before taking the cable to the site. Two pieces of cable can be joined together simply by bolting end couplings together, bridging with links and fitting a cover, with the result that much time and labour are saved. A third or fourth cable may be connected without disturbing a straight-through connection. No soldering is required and the cable links may be removed to isolate a cable. Cable ends supplied separately may be bolted together to form two, three, or four-way cable couplings or may be assembled with a flame-proof lantern with a body shaped so that it may be bolted to a single end or two or three-way assemblies. Two lanterns may be bolted one on either side of a straight-through coupling. Copper links connect the lantern terminals with those of the couplings in the same way as



FLAME-PROOF ELECTRIC LIGHTING EQUIPMENT

the couplings are connected together. The terminal covers will fit any arrangement of couplings or couplings and lanterns which will take a 40 or 60-watt bayonet cap lamp.

The heat-resisting glass well of these lanterns is said to be undamaged if cold water be poured upon it. After it is cemented into a bezel each glass is tested hydraulically at an internal pressure of 80 lb. per square inch. As the bezel, to which a sturdy wire guard is fitted to protect the glass, is composed of brass, rust marks which would obscure the light do not form on the glass. All assemblies may be slung or fastened to the ceiling, wall, or pit prop, and bolts are provided so that lugs or straps, fashioned to suit the prevailing conditions, may be fastened to any assembly. The upper and lower illustrations show a lantern attached to the end of a cable and a three-way cable coupling with lantern respectively.

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Factory Organisation and Administration. Fifth edition. By H. Diemer. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 24s. net.

Practical Performance Prediction of Aircraft. By Lieut.-Colonel J. O. Blyth, O.B.E. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 5s. net.

Practical Electric Cable Jointing: The Plumber-Jointer and His Craft. By W. Maskery. London: The Technical Press, Ltd., 5, Ave Maria-lane, E.C.4. Price 5s. net.

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Corrosion: Causes and Prevention. Second edition. By F. N. Speller, D.Sc. London: McGraw Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 42s. net.

The Story of Telford: The Rise of Civil Engineering. By Sir Alexander Gibb, G.B.E., C.B. London: Alexander MacLehose and Co., 58, Bloomsbury-street, W.C.1. Price 16s. net.

Hints to Travellers: Vol. I, Survey and Field Astronomy. Eleventh edition. By E. A. Reeves. London: Royal Geographical Society, Kensington-gore, S.W.7. Price 16s. net.

The Gas Supply of Glasgow: A Historical Account of the Inauguration and Development of the Corporation Gas Supply. Glasgow: John Menzies and Co., Ltd., 90, West Nile-street.

Strength and Flexibility of Corrugated Piping.*

By ROBERT L. DENNISON.

No. III.

(*Continued from page 334, September 27th.*)

Experimental Methods.—The Determination of the Flexibility of the Piping.

The Necessity for Establishing the Load-deflection Characteristics.—Since the specific strain type of fatigue testing machine imposes a definite deflection on the pipe, the bending moments and the consequent applied nominal stresses could be determined only from a knowledge of the relationship between the load and deflection of the specimen under consideration. In order to establish the load-deflection characteristics, each pipe shape was

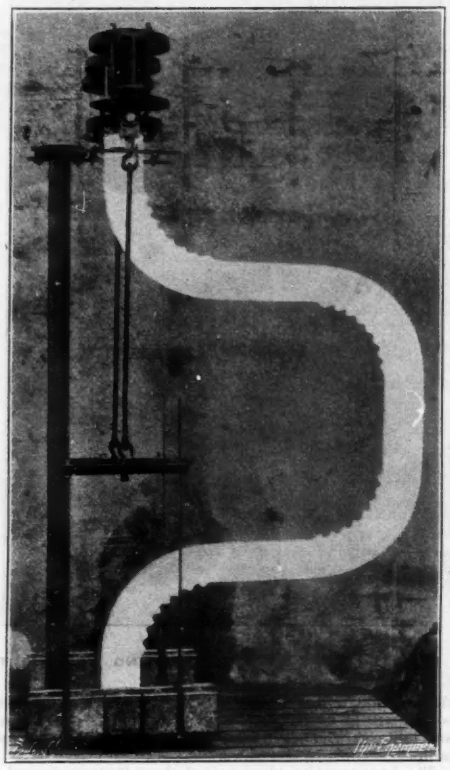


FIG. 8—EXPANSION U-BEND ERECTED FOR LOAD DEFLECTION MEASUREMENTS—FREE END

mounted with one end firmly secured to a heavy steel foundation plate and deadweight loads applied to the other end. Deflections were measured by means of micrometers with increments of applied load. Small balls, acting as gauge points for the measurements, were attached to the pipe flanges and to battens which were fixed to the foundation. Figs. 8–11 give views of typical arrangements for the load-deflection determinations.

The End Conditions.—Consider a pipe bend with its end flanges firmly fixed and subjected to an increase of temperature. The expansion of the pipe line will cause the flanges to exert certain forces and moments on the anchorages which may be resolved into a force perpendicular to the flange, a force parallel to the flange in the plane of the bend, and a couple also in the plane of the bend. This is called a fixed end condition. If the two forces continue to act, but the couple is removed, the flange is thus permitted to rotate and the condition is known as free end.

The fixed end condition was simulated in load deflection testing as shown in Fig. 9. Here the restraining force

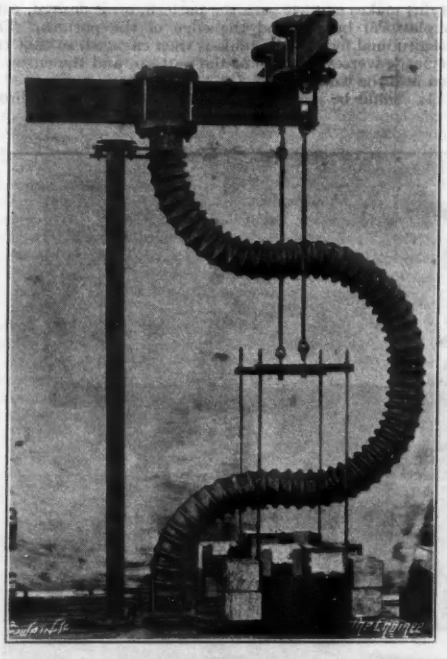


FIG. 9—EXPANSION U-BEND ERECTED FOR LOAD-DEFLECTION MEASUREMENTS—FIXED END

parallel to the flange in the plane of the bend is clearly zero. It is known from mechanics that a force and a couple acting in the same plane may be replaced by a single force whose moment arm is equal to the value of the couple

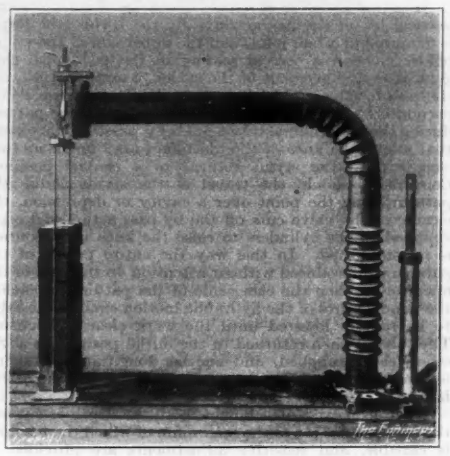


FIG. 10—QUARTER-BEND ERECTED FOR LOAD-DEFLECTION MEASUREMENTS

divided by this force. It will be seen from the photograph that this is accomplished by the method of loading shown. Here, as the load is applied, the flange moves in parallel planes. This condition was checked on test by a spirit level mounted on the upper flange. The proper value for the moment arm was first computed. Any subsequent minor adjustment necessary was indicated by the level.

Fig. 10 shows the simulation of the free end condition. Here the restraining moment is absent and rotation of the flange is therefore permitted.

There is a slight discrepancy between the state of affairs governing a load-deflection or fatigue test and the conditions actually obtaining in service. In the test conditions the forces and couples are applied on the cold or unexpanded pipe and hence on a pipe shape slightly different, from a dimensional standpoint, from the same pipe under elevated temperatures in service. This difference, however, is so slight that it may be disregarded for all practical purposes. It may be remarked that pipes in service will probably operate at some condition intermediate between the free end and fixed end conditions, and that the nature of these end conditions will have a decided effect on the stresses produced in the pipe itself.

Results of Load-deflection Determinations.—Figs. 12–18, inclusive, give graphs showing the load-deflection relation-

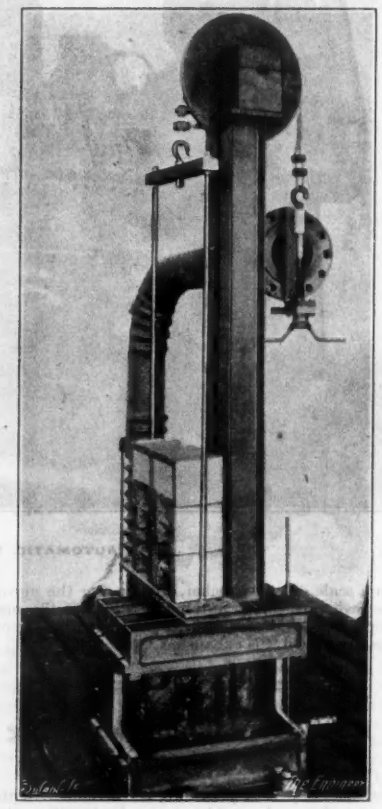


FIG. 11—QUARTER-BEND ERECTED FOR LOAD-DEFLECTION MEASUREMENTS

ship for each of the pipe shapes in the A, B, and C series of piping. At least one pipe shape of each type was tested for each of the A, B, and C series of piping. The remaining bends were checked for agreement with the typical similar shape before fatigue testing. The graphs also indicate the methods of loading and the points of deflection measurement. The effect of cold work on raising of the primitive elastic limit may be noted on those graphs which show the load-deflection characteristics after repeated loading.

The Flexibility Factor.—The flexibility factor V is defined as the ratio between the deflection of a section of corrugated or creased piping under a certain load to the deflection of a section of smooth-walled piping of the same length loaded in the same manner and by the same amount, both pipes considered to be the same basic wall thickness and the same basic internal diameter. In brief, it is the ratio of the flexibility of the corrugated or creased pipe to the flexibility of a similarly dimensioned smooth-walled pipe. As is the case with the factor K, developed by Dr. Karman, the flexibility factor V may be considered

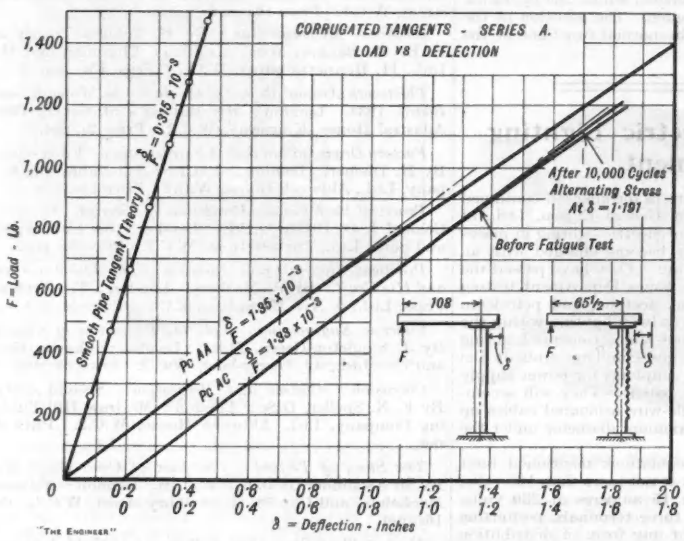


FIG. 12—LOAD-DEFLECTION CURVES FOR CORRUGATED TANGENTS —SERIES A

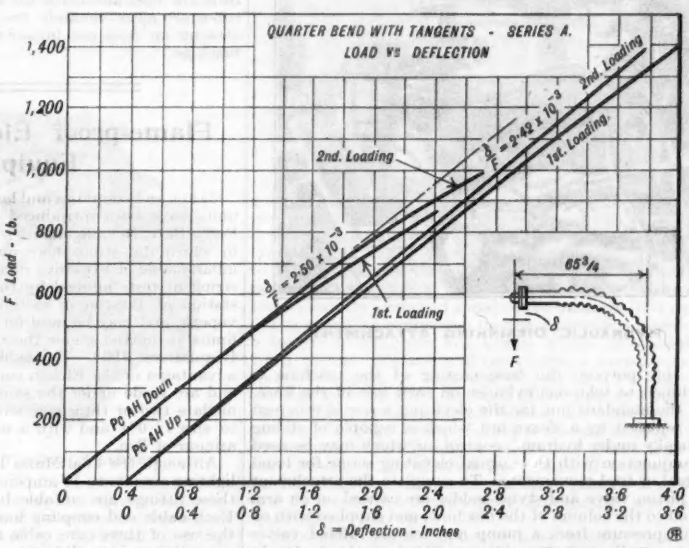


FIG. 13—LOAD-DEFLECTION CURVES FOR CORRUGATED QUARTER-BENDS —SERIES A

* Dissertation submitted to the Advisory Board of the School of Engineering of the Johns Hopkins University for the degree of Doctor of Engineering.

as modifying the flexural rigidity of the pipe shape considered.

In determining the flexibility of the piping, the grapho-analytical method of calculating deflections, combined with the principle of superposition, is used.[19] This method has been developed by the Detroit-Edison Company, which has published formulæ for the areas of the bending moment diagrams, together with formulæ for rotations and deflections, for various combinations of loadings applied to straight tangents and also quarter bends.

It is proposed in the subsequent sections to investigate the value of the flexibility factor V for the following pipe shapes :—

(*a*) The straight tangent, Series A.
(*b*) The straight tangent, Series B.
(*c*) The corrugated arc, Series A.
(*d*) The creased arc, Series C.

The flexibility factors to be developed will apply directly to the corrugated or creased bend shapes considered, and are entirely unassociated with the effect of added tangent lengths of piping. Thus, in computing the flexibility of corrugated tangents, the factor given applies to the corrugated section only, the effect due to the smooth pipe tangent length at the ends being eliminated by computation. Similarly, the flexibility factors given for the corrugated and creased arcs apply directly to the arc itself, and do not include the effect of tangent lengths beyond the 90 deg. of arc.

The Flexibility of Straight Tangents.—Series A.—The moment area diagram for piece A C is shown in Fig. 19.

(1) $E\,I\,\delta=\frac{\psi\,l}{2}\,\frac{(4450\,V+608)\times 75\cdot 75}{2}$

(2) $I=28\cdot 14$ (on basic pipe dimensions of 6·625in. O.D. and 0·280in. wall thickness).

(3) $\delta=1\cdot 33\times 10^{3}$ inches per lb. load (Fig. 12).

(4) $E=29\cdot 7\times 10^{6}$ lb. per square inch (by test).

[19] See "Applied Elasticity" by S. Timoshenko and J. M. Lessells, Section 23.

Substituting from equations (2), (3), and (4) in (1), and solving for V,

(5) $V=6\cdot 46$.

A similar computation for piece A A gives a value of $V=6\cdot 4$.

The Flexibility of Corrugated Arcs—Series A.—The moment area diagram for piece A H is shown in Fig. 19. It is assumed that, as demonstrated in the previous section, the flexibility factor of the tangent sections of this bend is 6·5.

$E\,I\,\delta_c=\psi_b\,l = 372{,}000\ F.$
$= \psi_f\ .\ 0\cdot 7854\ R = 7275\ V\ F$
$= \psi_m\ .\ 0\cdot 637\ R = 19{,}750\ V\ F.$

$E\,I\,\delta_d=\psi_c\,l = 754{,}000\ F + 81{,}600\ V\ F$
$= \psi_f\,\frac{2}{3}\,l = 160{,}100\ F$
$= \psi_m\,\frac{1}{2} = 23{,}600\ F.$

(1) $\Sigma\,E\,I\,\delta = 1{,}309{,}700\ F + 108{,}625\ V\ F.$

(2) $E=29\cdot 7\times 10^{6}$ (by test).

(3) $I=28\cdot 14.$

(4) $\delta=2\cdot 50\times 10^{-3}\ F$ (Fig. 13).

Substituting from (2), (3), and (4) in (1), and solving for V,

(5) $V=7\cdot 2.$

This factor is approximately the same as the value of the flexibility factor for the straight tangent. As might be expected, it is somewhat higher, possibly because of the deformation of the corrugations where the pipe is formed into an arc.

Dr. Karman's K value for a smooth-walled pipe arc of similar major dimensions is as follows :—

$$K=\frac{10+12\,\lambda^{2}}{1+12\,\lambda^{2}}$$

where $\lambda=\frac{t\,R}{r^{2}}=0\cdot 584$ and $\lambda^{2}=0\cdot 341$.

(6) hence $K=2\cdot 76$.

This indicates that this theoretical smooth pipe arc would be 2·76 times as flexible as an arc where no flattening occurred. This value of K for the smooth arc is comparable to the value of V for the corrugated arc. Hence V/K =relative flexibility=2·61. Therefore the corrugated arc is 2·61 times as flexible as a theoretical smooth arc having the same major dimensions.

The Flexibility of Straight Tangents.—Series B.—The flexibility of the corrugated tangents of Series B, computed in the same manner as for Series A, gives the following results :—

Piece B A, V=6·4.
,, B B, V=6·6.
,, B C, V=6·4.

The Flexibility of the Creased Arc.—Series C.—The flexibility of the creased arc of Series C, computed in the same manner as the corrugated arc of Series A, gives the following results :—

Piece C A, V=5·1.
,, C B, V=5·0.
,, C C, V=5·0.

The corresponding value of K for a theoretical smooth pipe arc of the same major dimensions is 3·79. Hence, assuming an average value of V to be 5·0, the creased arc appears to be approximately 32 per cent. more flexible than the theoretical smooth arc.

A Summation of Flexibility Results.—The flexibility

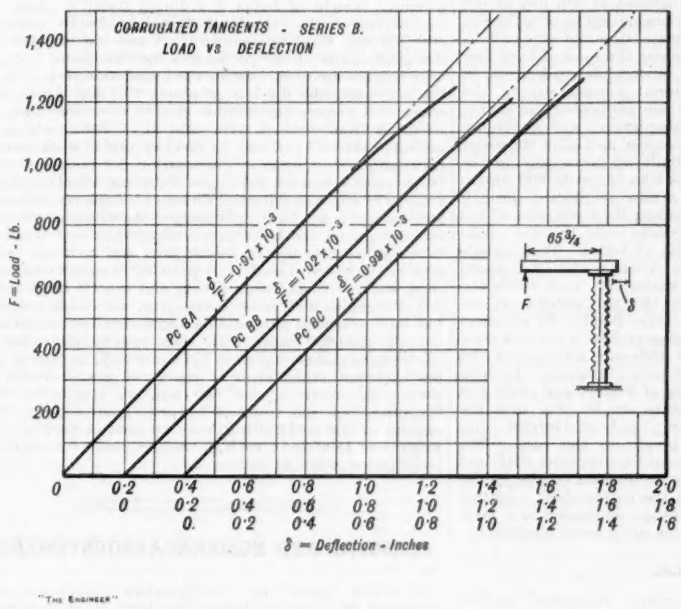


FIG. 14—LOAD - DEFLECTION CURVES FOR CORRUGATED TANGENTS—SERIES B

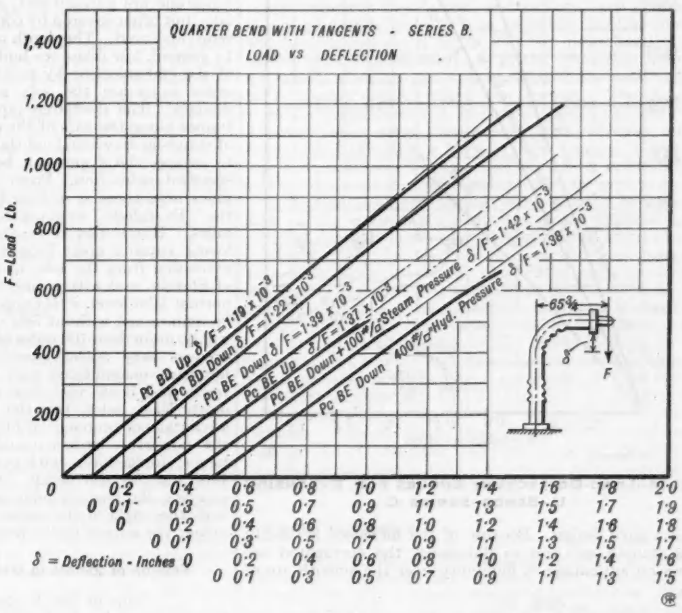


FIG. 15—LOAD - DEFLECTION CURVES FOR QUARTER BENDS—SERIES B

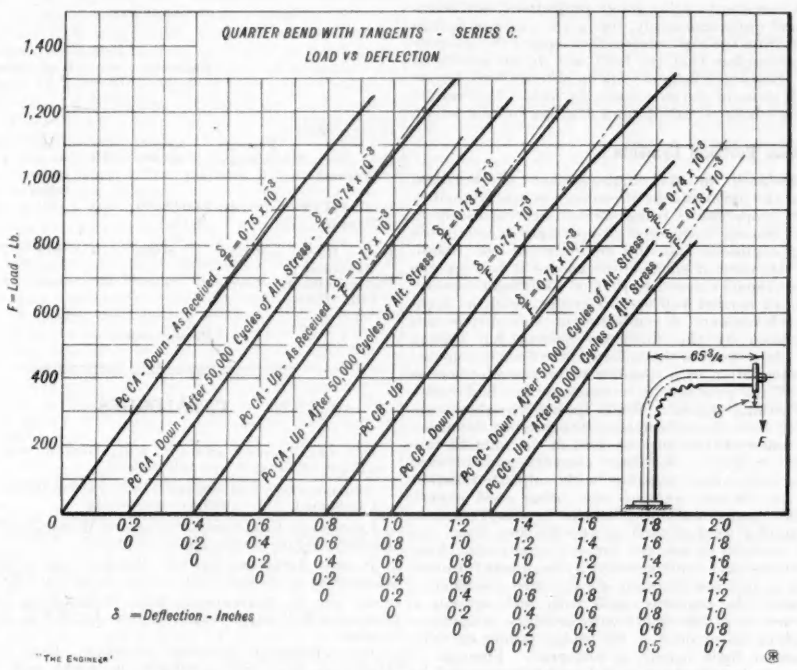

QUARTER BEND WITH TANGENTS - SERIES C.
LOAD VS DEFLECTION
F = Load - Lb.
δ = Deflection - Inches
Pc CA - Down - As Received
Pc CA - Down - After 50,000 Cycles of Alt. Stress
Pc CA - Up - As Received
Pc CA - Up - After 50,000 Cycles of Alt. Stress
Pc CB - Up
Pc CB - Down
Pc CC - Down - After 50,000 Cycles of Alt. Stress
Pc CC - Up - After 50,000 Cycles of Alt. Stress
65 3/4
"THE ENGINEER"

FIG. 16—LOAD - DEFLECTION CURVES FOR QUARTER BENDS—SERIES C

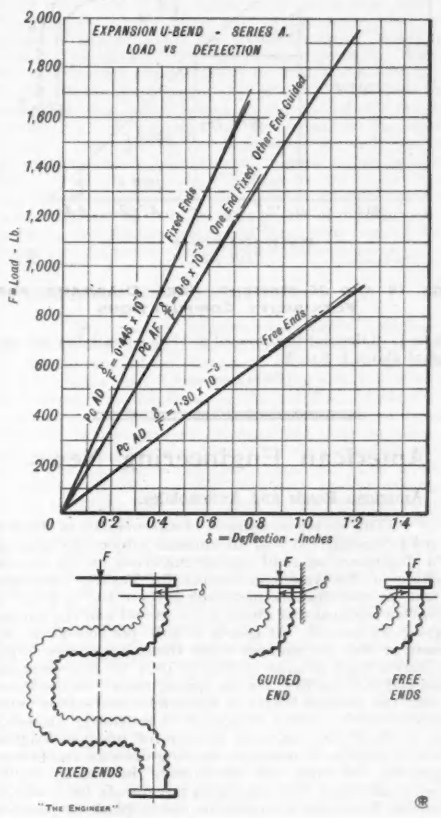


FIG. 17—LOAD - DEFLECTION CURVES FOR EXPANSION U-BENDS—SERIES A

factor for all tangents tested may be taken as 6. Although the corrugated arc may show a slightly higher flexibility factor, this value of 6 should also be used for the arc in

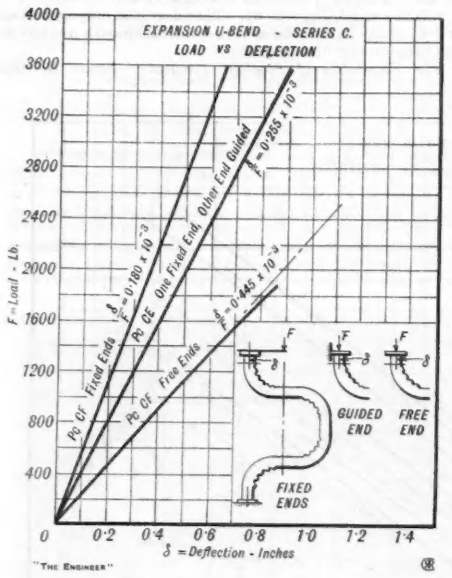

EXPANSION U-BEND - SERIES C.
LOAD vs DEFLECTION
F = Load - Lb.
δ = Deflection - Inches
Pc CF Fixed Ends
Pc CE One Fixed End, Other End Guided
Pc CF Free Ends
δ/F = 0·180 x 10⁻³
δ/F = 0·255 x 10⁻³
δ/F = 0·445 x 10⁻³
GUIDED END
FREE END
FIXED ENDS
"THE ENGINEER"

FIG. 18—LOAD-DEFLECTION CURVES FOR EXPANSION U-BENDS—SERIES C

conservative design. Because of the increased flexibility of a smooth arc due to flattening, the corrugated arc shows an advantage in flexibility over the smooth arc of

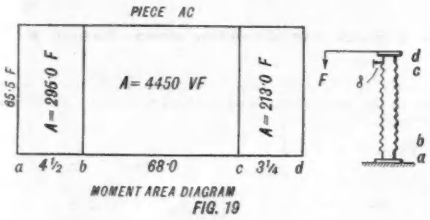


FIG. 19

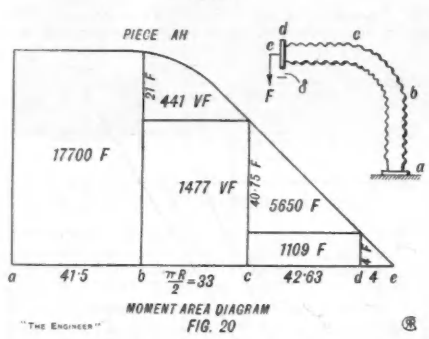


FIG. 20

FIGS. 19 AND 20—MOMENT AREA DIAGRAMS FOR FLEXIBILITY COMPUTATIONS

2·6 to 1. Likewise the creased arc has a flexibility advantage of about 1·3 to 1.

(To be continued.)

American Engineering News.

American Roads and Automobiles.

THE spring equipment of automobiles in relation to road construction was an unusual subject brought up in a discussion on road paving materials at the annual meeting of the American Society for Testing Materials. It was claimed that the unsprung parts of the cars have a vibration frequency of about 9 per second and the sprung parts 2 per second. At speeds of 45ft. per second in city streets or 90ft. on country roads these frequencies imply resonance wave lengths of 5ft. to 10ft. for the unsprung mass and 20ft. to 45ft. for the sprung mass. As the latter is near the average length of highway construction units, the result is bad riding of the car. The remedy suggested was to build the roads in sections of unequal lengths. Through main or trunk roads for long-distance travel were suggested, to take the enormously increasing traffic. They would have two separated pavements for traffic in opposite directions, a surface as nearly plane as possible, gradients such that any vehicle could maintain at least 20 miles an hour, a sight distance of 1500ft., and full fencing. The plane surface requirement is inspired by accidents caused by minor irregularities that are not noticed at other than high speeds. In tire manufacture the mileage life has been increased from 2000 or 3000 to 25,000 or in some cases 50,000 miles. While main roads for high-speed travel must necessarily be costly, it is important that in developing the country road system some way should be found to build more miles with less money. This means soil studies for better stability of formation level and also further development of low-cost surfacing or "flexible" road construction. Cracks in asphaltic or bituminous road paving are found to occur most generally in the spring, and are attributed to movements in the subsoil as the frost comes out of the ground. Methods of refining asphalts have little relation to the resistance of the paving to cracking, but mixtures containing the highest proportion of asphalt—and asphalt of the highest penetration—are most resistant to cracking at low temperatures.

Dike Building by Hydraulic Dredges.

In the construction of 66 miles of levee or dike along the south shore of Lake Okeechobee, in Florida, placement by hydraulic dredges has been adopted for the 30 million cubic yards of material required. Marl and limestone are encountered, sometimes at the bed of the lake, but often covered by considerable depths of sea shells, sand, and mud. The depth of water does not exceed 20ft. In general, low dikes are built along the lines of both toes of the embankment by means of dragline excavators, in order to retain the soft material pumped in by the dredges. The discharge pipes are supported on timber frames along the axis of the embankment, and by the use of stop boards, which hold the material and allow the water to escape, the slopes can be built up accurately to the specified inclination. From this lake of nearly 600 square miles area there is ordinarily a flow southward through the "Everglade" swamps extending for a distance of 100 miles. Hurricanes carry the water over the low shore levels, causing great loss of life at times. With canals extending from the lake to the Atlantic and Gulf coasts of Florida, and with a ring of levees 17ft. high above the normal lake level, it is expected that this water level can be maintained without fear of future floods. In all, there will be more than 100 miles of levee or dike. The hydraulic dredges have cutter heads of different forms, and the materials encountered vary at short intervals. In rock work, drill boats with four sets of leaders and drills put down blast holes, but the strata are so thin that the advantage or economy of blasting has been doubted, since the powerful dredges could break up the rock. The largest dredge has a 500 h.p. motor for the cutter shaft and 1800 h.p. for the pump. The inclination of the ladder carrying the suction pipe and the cutter shaft, together with the angle of the cutter blades, determine to a large extent the output of the machine in different materials.

Fatigue of Metals in Gearing.

Tests in the United States of several hundred motor car axles and differential pinions constitute a highly important addition to the knowledge of the complicated subject of the fatigue of metals. In these tests each complete rear axle assembly was run in a motor-driven machine under full low gear torque until failure. As a rule failure occurred by the fracture of teeth in the differential pinion. The axle gearings were of numerous sizes and designs, and had different qualities of machining. Poor finish at the root of the teeth contributed to earlier failure. The tooth stresses in the several tests were plotted against number of cycles at failure, giving a typical stress cycle chart. On comparing the test results with service records of different gears applied to automobiles the results were shown to be closely alike. From these tests it was concluded that the gear failures under test and in service were fatigue failures under repeated cantilever loading of the pinion teeth. Variations in design and manufacture have greater effect on gear life than variations in material or heat treatment. In fact, the concentration of stress due to rough cutting of teeth so greatly affects the strength that the life of pinions may be increased ten to twenty times by greater care in workmanship. In a number of cases the axle life in the tests was equivalent only to about 30 miles of driving in low gear. This is taken to prove the controlling influence of occasional cycles of greatly increased stress occurring in the course of cycles of moderate stress. In actual motor cars, designs with sharp re-entrant angles, rough projections, and sharp fins are found quite commonly, but when a fatigue failure has resulted from the high stresses thus caused the designer is likely to complain that the fault was in the quality of the metal. Results of fatigue tests on notched bars agreed closely with those of the axle assembly tests. Test results have also corroborated calculations of stress concentration.

American Portland Cements.

Research in the improvement of Portland cement and the development of cements of special quality and special properties is being carried out vigorously in the United States, with close co-operation between the purchasing engineers and the engineers of the manufacturers. In view of such developments it has become desirable to prepare a new definition of "Portland cement" to cover both normal and special grades—such as high-early-strength cement. A committee for this purpose has been appointed by the American Society for Testing Materials. As a result of this situation the Society rejected the recommendation of a committee for the adoption as standard of its proposed specifications for high-early-strength Portland cement. While special ingredients are required for such special cements, the present definition limits the material that may be used in the manufacture of cement. Study of low-heat cements and blended cements is continuing, together with sulphate-resistant cements. A low-heat cement now being used experimentally for dams and other works in the Tennessee Valley is similar to that used on the Boulder Dam, but somewhat modified to suit the climatic conditions. Very similar cements have been specified by engineers for other large dams, so that the adoption of a standard specification is important. As concrete made with such cement is rather darker than that made with ordinary cements, it may be advisable to omit it for bridge railing or other parts where a light colour is preferred. Fineness of cement is now frequently specified to be determined by the Wagner turbidimeter method, rather than the older method of the 200-mesh sieve, and this is found to result in less cost for placing concrete made with cement graded by the turbidimeter. A difficulty in the past has been the variable results of identical tests made at different laboratories, owing to the human factor and local conditions. This situation is being improved through a committee which aims at uniformity in methods and results.

American Locomotive Developments.

Reports presented at the annual meeting of the Mechanical Division of the Association of American Railways, which is composed of locomotive superintendents and mechanical engineers, indicate that its activities are being resumed after a few years of comparative inaction. As to water-tube boilers, the Baltimore and Ohio Railroad now has nine in service, of the same general design, carrying 350 lb. pressure. The Delaware and Hudson uses 350 lb. to 500 lb. pressure; it finds no more difficulties with maintenance than in ordinary boilers carrying 350 lb. Some disadvantages of high pressures in ordinary boilers are increased failures of fire-box sheets and stay bolts, higher cost for material if special metal is used, and increased weight of boiler if ordinary metal is used. It was suggested that the limit should be 500 lb. pressure and 750 deg. total temperature. A new development is the application of air preheaters for fire-boxes. Steam tube heaters are placed under the foundation ring, so that the air enters the fire-box at about 200 deg. Fah. The effect is to reduce the trouble of side sheet maintenance resulting from contact with cold air. Tests indicate a saving of about 7 per cent. in fuel per unit of work, with a corresponding increase in evaporation per pound of coal. Other innovations are disc types of driving wheel centres—which are still experimental although in use on some 300 locomotives; and built-up driving axles, which are proving satisfactory on the Delaware, Lackawanna and Western. While roller bearings on crank pins and rods are satisfactory, they are stated to require more care in running shed work, with precision fitting and careful lubrication. A 4–6–2 engine with roller bearings on the crank, coupling rod, and crosshead pins, and having 95 tons on the drivers, has run 100,000 miles with such results as to justify equipping another engine in the same way, including also the excentric crank arms of the valve gear. As to oil-electric locomotives, the 600 h.p. oil engine is most favoured, but the trend is towards greater power and engines of 800 to 1200 h.p. may be used in yard service. Engines of 1800 and 2000 h.p. are being built for main line passenger and freight service.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

B. AND S. MASSEY, Ltd., of Openshaw, Manchester, have appointed Mr. Hugh A. Wallace, S.I. Mech. E., as their representative in the Midlands and North of England, to deal, from headquarters, with all matters concerning steam and pneumatic power hammers, drop stamping plant, &c.

MR. N. S. SMITH and Mr. D. Jewell, who have been engaged in the motor and engineering trades since before the war, have recently formed a new company, Smith and Jewell, Ltd., to undertake motor body repairs—particularly pressed steel bodywork, cellulosing, painting, body building, and mechanical work—for the motor trade. The company's works are situated at 52–62, Lower Kennington-lane, S.E.11.

CONTRACTS AND ORDERS.

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

ELLIOTT BROTHERS (London), Ltd., have received an order from John Brown and Co., Ltd., for twenty-four complete sets of Siemens CO_2 (flue gas analysis) equipment, namely, a set for each of the main boilers on the Cunard-White Star liner "Queen Mary."

RICHARDSONS WESTGARTH-BROWN BOVERI, Ltd., Hartlepool inform us that between April 1st and September 30th, 1935, the following orders for Velox boilers were placed:—

New Orders.

	Capacity, lb./hr.	Pressure, lb./sq. in. g.	Temp., ° F.	Feed water temp., ° F.	Fuel.
Remy a Gaillon (France)	26,400	400	750	140	Oil
Issy - les - Moulineaux (France)	10,000	213	Dry satu-rated	175	Oil
Ciudad Universitaria, Madrid	53,000,000 B.Th.U./hr.	215	390	—	Oil*
Brown Boveri and Co., Mannheim	8,800	770	875	175	Tar oil
Palestine Electric Corp., Ltd., Haifa	70,000	370	840	140	Oil*

* Repeat order.

CATALOGUES.

DOUGLAS, LAWSON AND CO., Ltd., Birstall, near Leeds.—Catalogue of wrought iron belt pulleys.

ENGLISH STEEL CORPORATION, Ltd., Vickers Works, Sheffield.—Catalogue C 2/1 of dredger components.

FRASER AND CHALMERS ENGINEERING WORKS, Erith, Kent.—Booklet 7385 on cyanide plant equipment.

DORMAN, LONG AND CO., Ltd., Middlesbrough.—Third edition of the catalogue of steel plates, joists, and sections, &c.

M. AND C. SWITCHGEAR, Ltd., Kirkintilloch, Glasgow.—Pamphlet R 61/2A, dealing with type A 219 A.C. push-button starters.

WILD-BARFIELD ELECTRIC FURNACES, Ltd., North-road, Holloway, N.7.—New catalogue on works and laboratory furnaces.

J. M. HENDERSON AND CO., Ltd., Aberdeen.—Leaflet 66–1 E., describing the installation of an aerial cableway at Croft, near Leicester.

ELECTRIC DRIVING.—Our attention has been called to inaccurate figures given in the brief description of the electrically driven conveyor illustrated in Fig. 44 on page 284 of our issue of September 20th. The 960 r.p.m. motor is rated at 15 h.p. When running at 150ft. per minute and travelling 450 yards on the level, the conveyor has an output of 60 tons per hour and 80 tons when running at 200ft. per minute over a distance of 350 yards.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

Continental Export Prices.

Considerable interest attaches to the meetings of the British and Continental steel makers, which take place in London this week, as it is understood that the details of the export agreement are to be discussed. Further meetings will be held on the Continent, the next one having been fixed for a date later in the month at Brussels. It was expected at one time that the question of making an all-round increase in export prices would be considered. This has been denied, and it is now suggested that an advance may follow the Brussels meeting. It is doubtful, however, if it will be considered politic to make a general increase, and it is more likely that this will be done by degrees. The first step may be to come to an arrangement to bring the Continental extras list for all steel materials into line with the British. This has been done in the case of plates, with the result that the prices of certain Continental specifications have been appreciably increased. It is understood that the British and Continental makers are now working on the Continental extras lists for sections with a view to bringing these to the British level. It remains to be seen how these schemes will work out in practice. So far no sales of plates have been reported at the new prices, and it is quite easy for buyers to make contracts at the old quotations, as many merchants appear to be holding long-term contracts against which they can specify. The position is not made easier by the fact that export trade with those markets which habitually take Continental steel is decidedly poor. Quite recently the Continental steel makers reduced their prices for China and the Far East in an effort to stimulate business. It is said that this move has been partly successful and that it has to some extent met Japanese competition. The volume of orders reaching the Continental works from other markets has also been on a disappointing scale and the continuation of barter and compensation business by Germany has created a considerable amount of feeling. Assertions are made that German steel works have taken the most valuable part of the seasonal South American business by these methods. Another barter agreement has also been entered into with South Africa, involving the exchange of goods valued at thirty million marks. The materials which Germany will send to South Africa under this arrangement will consist principally of steel and railway material.

The Pig Iron Market.

Not for many years has the pig iron market entered the autumn session with such a large proportion of the forward requirements of consumers so well covered. In this respect, 1935 has been a rather abnormal year. The uncertainties of the situation as a result of the Cartel negotiations and the talk of higher prices at the end of the summer conspired to provoke in consumers the idea that then was the time to buy, and an unusually large tonnage was bought for future delivery. Generally, consumers wait until they can gauge their requirements more closely, and as a rule contract for their supplies in the early autumn. It is not surprising, however, that this customary buying has failed to develop. On the other hand, the volume of small orders reaching the works from day to day is much larger than is usually the case, and this, taken in conjunction with the steady flow of specifications against contracts, points to a satisfactory consumption of pig iron. The Cleveland makers are in the comfortable position of having sold their output before it is produced, and hold contracts for delivery over the first quarter of next year, amounting to a substantial total. New business, which has been of a hand-to-mouth description for some time, fluctuates, and during the past week has been rather poor. The makers, however, do not regard this with any concern, as at times during recent weeks the demand has had to be met by the withdrawal of pig iron from the diminishing stocks. The Midland market pursues a satisfactory but uneventful course. The current demand is steady, but lately there has been a noticeable increase in the size of the specifications against running contracts. At some works a fair tonnage has been taken out of stock during the past few weeks, and it is possible that the consumption of pig iron exceeds the present output. The Scottish pig iron industry is experiencing a steady demand from local users, and this is sufficient to take care of practically the whole of the production. New buying in the hematite pig iron market has been quiet, but heavy deliveries continue to be made against existing contracts.

The North-East Coast and Yorkshire.

Busy conditions rule at all the North-East Coast steel works, and most makers are experiencing considerable pressure from consumers anxious to obtain delivery. The demand is particularly strong for billets, and to a lesser extent for sheet bars. Although it is understood that purchases against the Continental quota for the period beginning in October will soon be possible, this has had no influence upon the volume of business in British material. Many consumers have long-distance contracts with the steel works, which are assured of full working in this department for some months to come. The constructional engineers on this coast, also, are providing a good outlet for steel, and there seems no likelihood of the demand from this quarter declining in the near future. Business in joists and sections has seldom been better, and although requirements may fluctuate a little, specifications against contracts continue to reach the works at a satisfactory rate. More work would be welcomed by the shipbuilding industry, but the builders are hoping to benefit from the Government's new programme of naval construction. The expectations that the defences of the country will be substantially strengthened has also encouraged hopes of increased work in departments of the industry which have not been really busy for a long time. The sheet mills have been able to increase their bookings lately, and the improvement in this section, which was long overdue, is one of the satisfactory features of the position. The demand is still largely upon home account, but export buyers are showing more interest in the market. The mills producing railway material have worked off most of the heavy contracts which they had on their books, and would be glad of fresh business of this description. The Yorkshire iron and steel industry has maintained a high rate of activity throughout most of this year, and some of the Sheffield works are operating practically at capacity. The demand for basic billets, and, on a rather less active scale, for acid billets, shows signs of expanding, although even as it is the works are pressed to keep up their deliveries. The strip mills are well employed, and lately have experienced a fresh influx of orders.

The Midlands and South Wales.

In the Midlands practically all the steel works are comfortably situated. Not only have they a good reserve of orders on their books, but new business is coming forward in sufficient volume to make good the completed work. Lately there have been signs that the demand, as is usually the case in the autumn, will expand, and the makers are looking forward to busy conditions for the remainder of the year. Business in structural steel fluctuates somewhat, but this week a number of new orders have been placed, and the general tendency of the market for joists and sections is to broaden. Many of the structural engineers in the Midlands have big contracts in hand which absorb large quantities of steel, and although their requirements against most of these have been covered, the new work in sight promises to maintain the demand. Business in small bars has been brisk of late, and the majority of the re-rolling works are well supplied with orders. The position in this branch of the industry has not altered, and there is still at times keen competition between the associated and the unassociated works. It is not expected that there will be any change in steel prices during the remainder of the year, but the present quotations are firmly held. The strip requirements of consumers are important, and as imports of this material have been rigidly restricted under the Anglo-Continental agreement, the British producers are experiencing a steady pressure of orders. Quotations are unchanged, the associated price being £9 7s., whilst unassociated firms quote lower figures, although lately there has been a tendency for the latter to stiffen their prices. The buying of steel by the collieries has been fairly active, and prices are unchanged, with light arches quoted at £8 5s. and heavy at £8 15s. d/d Midlands, including accessories. Roofing bars are quoted at £6 5s. to £7 10s. Busy conditions rule in the South Wales steel industry; business in structural steel having been especially brisk. The works producing railway material are also well employed, and the production of semis is at a satisfactory rate. The demand for the latter material, in fact, seems to be increasing, if anything, partly as a result of slightly busier conditions in the tin-plate industry, which is working at about 58 per cent. of capacity.

Current Business.

It is announced that the British naval construction programme for 1935 will consist of twenty-one ships. It is estimated that the cost will amount to £10,000,000, and the programme is expected to be spread over nearly three years. The Manchester Corporation is seeking power from the Electricity Commissioners to borrow £470,000 to extend the Barton power station. James Howden and Co., Ltd., of Glasgow, have obtained a contract for a complete equipment of their patented turbulent-flow air preheaters for the boilers of five cargo steamers building in Germany. The old Cyclops Works at Sheffield, which was the principal steel and engineering works of Cammell, Laird and Co., Ltd., is being re-equipped by the English Steel Corporation, Ltd. It is stated that within a week or two the whole oil-from-coal plant of Coal and Allied Industries, Ltd., at Seaham Harbour will be producing. It is anticipated that the yearly output will be 4,000,000 gallons of motor spirit, 4,000,000 gallons of Diesel oil, and 100,000 tons of smokeless fuel. Alex. Stephen and Sons, Ltd., of Linthouse, have obtained an order for a motor cargo vessel of 3500 tons from the Union Steamship Company, of New Zealand, Ltd. The Department of Overseas Trade announces that the following contracts are open for tender:—Indian Stores Department: Supply of welded bogies (India, October 22nd); water sluice valves, various sizes from 2in. to 12in. bore (New Delhi, October 22nd); fish bolts and dog spikes (New Delhi, October 24th). South African Railways and Harbours: Supply and delivery of structural steelwork for a new locomotive shop at Salt River (Johannesburg, November 18th). Iranian Department of Industry and Mines: Screening and washing coal apparatus for Shemshak (Tehran, November 30th); apparatus for screening and briquetting coal for Zirab (Tehran, November 20th).

Copper and Tin.

Business has been active in the electrolytic copper market, although the buying has not been on such a heavy scale in the United States since the price was firmly established at 9c. d/d. The American producers claim to have sold over 82,000 tons during September, and undoubtedly some of this was bulk buying by European Governments. Italy, it is understood, is still in the market for a large tonnage, a figure of 50,000 tons having been mentioned. The improvement in the conditions in this market is reflected in the higher export price, the quotation now being 8·77½c., or about £40 c.i.f. Europe. Some consumers apparently anticipate a further advance in the American domestic price, but this seems unlikely at the moment unless the American consumers again come into the market, and as they have purchased heavy quantities forward it is probable that the market will have a rest for a time. On the other hand, if the export price reaches parity with the American domestic quotation, it would not be surprising if the producers in that country again raised the former. The London standard copper market has developed a steady tone. At times there were some rather large offerings which were easily absorbed. Part of the buying is said to represent purchases by American producing interests who sold in this market some time ago and are now covering. . . . The tin market developed fresh activity in the early days of this week, but the market seems doubtful as to whether the rise in price was the result of an improvement in the demand, or was due to artificial manipulation. This attitude is, of course, one of the consequences of the control exercised over the market by the International Tin Committee and the unhealthy conditions which have ruled for so long. The backwardation has increased to over £13, much to the annoyance of the market, as this tends to check a great deal of legitimate industrial hedging. The September statistics show a decrease of 1564 tons in the visible supply, and this is taken to indicate that the tight conditions ruling of late may continue during October. Reports have been current that the International Tin Committee may call a special meeting to consider an increase in the quota, but no official announcement to this effect has been made.

Lead and Spelter.

The position in the lead market has not materially altered. If anything, the demand from consumers has strengthened and a large tonnage of lead is now passing into consumption. This is reflected in the rise in price, which has reached the highest figure registered for two or three years. Most of the consuming works appear to have covered themselves for some time ahead, and all the Empire metal reaching this country is apparently being delivered in satisfaction of these contracts. As a result there is little surplus metal left for the market, and some lead has had to be taken out of warehouse to fulfil September contracts. The strike at the Mexican smelter is still affecting supplies from that country. The Continental demand has been good, and whilst the international situation remains disturbed there is likely to be steady buying by foreign governments. The continuation of the building boom in this country is, of course, an important factor in the position and accounts for the large quantities of the metal which have been used for the manufacture of pipes and similar materials. It is generally believed that the world statistical position is steadily improving. The American figures for August, the most recent obtainable, show that the stocks in the United States at the end of that month were 227,583 tons, compared with 230,915 tons at the end of the previous month. . . . A steady tone has ruled in the spelter market, although the consumptive demand has not greatly improved. This metal, however, has benefited from the rise in the price of lead as the movement in the one market usually has a sympathetic influence upon the other. There have been no arrivals of foreign spelter recently, and foreign metal has been taken out of warehouse and delivered against September contracts.

Non-ferrous Metal Average Prices.

The marked improvement which occurred in the non-ferrous metal markets during September is shown in the London Metal Exchange official average prices. It is probable that to some extent the advance in prices last month was the result of the purchase of metals for war materials. This applies to many countries not directly involved in the present international dispute, since at such times there is a tendency for Governments to lay in stocks as a precautionary measure. The average quotation for cash copper improved to the extent of £1 7s. 11d. over that for August, whilst for three months the price was £1 8s. 5d. better. The average quotation for electrolytic copper showed an improvement of £1 19s. 10d.; for wire bars it was £2 0s. 3d., and for best selected £1 18s. 6d. higher than for August. A rise of 18s. 7d. was registered in the average price for cash tin, but for three months the average was 7s. 4d. below that for August. The advance in the lead price came too late in the month to be fully reflected in the averages, but the quotation showed an improvement of 9s. 9d. on shipment for the current month and for the third following month of 10s. 5d., the mean being 10s. 10d. higher. The better conditions which ruled in the spelter market during September are shown in the improvement of 14s. in the average price for shipment during the current month, whilst for shipment the third following month the quotation is 13s. 6d. up, the mean showing a rise of 13s. 9d. The following are the official average quotations for September:—

Standard Copper	Cash	£34	1	5⅜
	3 Months	£34	9	5 13/16
	Settlement	£34	1	6¼
Electrolytic Copper		£38	4	10¼
Electrolytic Wire Bars		£38	10	8½
Best Selected Copper		£37	9	4½
Standard Tin	Cash	£224	3	3⅜
	3 Months	£212	12	4¼
	Settlement	£224	2	7⅜
Lead	For shipment the current month	£16	5	2⅝
	For shipment the third following month	£16	6	3¼
	Mean	£16	5	9⅜
	Settlement	£16	5	8½
Spelter	For shipment the current month	£15	8	3⅜
	For shipment the third following month	£15	12	3⅝
	Mean	£15	10	3½
	Settlement	£15	8	5⅜

Current Prices for Metals and Fuels.

Makers' official home trade prices per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.; plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home.	Export.
	(*D/d Teesside Area*)	
N.E. Coast—	£ s. d.	£ s. d.
Hematite Mixed Nos.	3 10 6	3 2 0
No. 1	3 11 0	3 3 6
Cleveland— (*D/d Teesside Area*)		
No. 1	3 10 0	3 4 0
No. 3 G.M.B.	3 7 6	3 1 6
No. 4 Forge	3 6 6	3 0 6
Basic (*Less 5/– rebate*)	3 10 0	—
Midlands—		
Staffs.— (*Delivered to Black Country Station*)		
North Staffs. Foundry	3 11 0	—
„ „ Forge	3 6 6	—
Basic (*Less 5/– rebate*)	3 15 0	—
Northampton—		
Foundry No. 3	3 7 6	—
Forge	3 2 6	—
Derbyshire—		
No. 3 Foundry	3 11 0	—
Forge	3 6 0	—
Scotland—		
Hematite, f.o.t. furnaces	3 13 6	—
No. 1 Foundry, ditto	3 12 6	—
No. 3 Foundry, ditto	3 10 0	—
Basic, d/d (*Less 5/– rebate*)	3 10 0	—
N.W. Coast— Hematite Mixed Nos.	3 14 0 d/d Glasgow 3 18 6 „ Sheffield 4 4 6 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
Lancs.—	£ s. d.	£ s. d.
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
S. Yorks.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
Midlands—		
Crown Bars	9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
No. 3 quality	7 10 0	—
No. 4 „	8 0 0	—
Scotland—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. Coast—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

London and the South—	Home. £ s. d.	Export. £ s. d.
Angles	8 10 0	7 7 6
Tees	9 10 0	8 7 6
Joists	8 17 6	7 7 6
Channels	8 15 6	7 12 6
Rounds, 3in. and up	9 10 0	8 7 6
„ under 3in.	8 14 6	7 0 0
Flats, 5in. and under	8 14 6	7 0 0
Plates, ¼in. (basis)	9 0 0	7 15 0
„ ⅜in.	9 5 0	8 0 0
„ ½in.	9 10 0	8 5 0
„ ⅝in.	9 15 0	8 10 0
„ ¾in.	9 10 0	8 5 0
North-East Coast—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Plates, ¼in.	8 15 0	7 15 0
„ ⅜in.	9 0 0	8 0 0
„ ½in.	9 5 0	8 5 0
„ ⅝in.	9 10 0	8 10 0
„ ¾in.	9 5 0	8 5 0
Boiler Plates, ¾in.	9 5 0	—
Midlands, and Leeds and District—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ ⅜in.	9 2 6	8 0 0
„ ½in.	9 7 6	8 5 0
„ ⅝in.	9 12 6	8 10 0
„ ¾in.	9 5 0	8 5 0
Boiler Plates, ¾in.	9 7 6	7 15 0

STEEL (*continued*).

Glasgow and District—	Home. £ s. d.	Export. £ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 15 0	7 15 0
„ ⅜in.	9 0 0	8 0 0
„ ½in.	9 5 0	8 5 0
„ ⅝in.	9 10 0	8 10 0
„ ¾in.	9 5 0	8 5 0
Boiler Plates	9 5 0	—
South Wales Area—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 0
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ ⅜in.	9 2 6	8 0 0
„ ½in.	9 7 6	8 5 0
„ ⅝in.	9 12 6	8 10 0
„ ¾in.	9 10 0	8 5 0

Ireland—	Belfast. £ s. d.	Rest of Ireland. £ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ¼in. (basis)	9 0 0	9 2 6
„ ⅜in.	9 5 0	9 7 6
„ ½in.	9 10 0	9 12 6
„ ⅝in.	9 15 0	9 17 6
„ ¾in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

Sheets.	Home. £ s. d.	Export. £ s. d.
10-G to 13-G., f.o.r.	9 10 0	8 15 0
14-G. to 20-G., d/d	10 15 0	9 0 0
21-G. to 24-G., d/d	11 0 0	9 5 0
25-G. to 27-G., d/d	11 12 6	9 17 6

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots, 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 0 0
2-ton to 4-ton lots	13 7 6
Under 2 tons	15 0 0

Export: £12 15s. 0d., c.i.f. India.
„ £11 5s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel Ports, 18/2.
Tin-plate Bars, d/d South Wales Works, £5 5s. 0d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	6 12 6
„ Medium (0·42% to 0·60% C.)	7 2 6
„ Hard (0·61% to 0·85% C.)	7 12 6
„ „ (0·86% to 0·99% C.)	8 2 6
„ „ (1% C. and up)	8 12 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 to 250 tons	5 17 6
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/– per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£21 15 0	7/–
„ „ 6 p.c. to 8 p.c.	£21 0 0	7/–
„ „ 8 p.c. to 10 p.c.	£21 0 0	7/–
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£34 0 0	11/–
„ „ „ 1 p.c. carbon	£36 5 0	11/–
„ „ „ 0·50 p.c. carbon	£37 5 0	12/–
„ „ „ carbon free	9½d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose)	£10 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 15 0 scale 5/– p.u.	
„ „ 75 p.c.	£17 17 6 scale 6/– p.u.	
„ Vanadium	12/8 per lb.	
„ Molybdenum	4/6 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Cobalt	5/6 per lb.	

NON-FERROUS METALS.

Official Prices, October 2nd.

Copper—		
Cash	£35 0 0 to £35 1 3	
Three months	£35 6 3 to £35 7 6	
Electrolytic	£39 10 0 to £40 0 0	
Best Selected Ingots, d/d Birmingham	£39 10 0	
Sheets, Hot Rolled	£69 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	10½d.	10½d.
„ Brazed (basis)	10½d.	10½d.
Brass—		
Ingots, 70/30, d/d Birmingham	£31 0 0 to £32 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	9½d.	9½d.
„ Brazed	11½d.	11½d.
Tin—		
Cash	£223 0 0 to £225 0 0	
Three months	£214 15 0 to £215 0 0	
Lead	£17 10 0 to £17 11 3	
Spelter	£16 6 3 to £16 11 3	
Aluminium Ingots (British)	£100	

FUELS.

SCOTLAND.

Lanarkshire—	Export.
(f.o.b. Grangemouth)—Navigation Unscreened	13/3 to 13/6
„ Glasgow—Ell	15/–
„ „ Splint	17/6
Ayrshire—	
(f.o.b. Ports)—Steam	12/– to 12/6
Fifeshire—	
(f.o.b. Methil or Burntisland)—	
Prime Steam	13/9 to 14/–
Unscreened Navigation	13/3 to 13/6
Lothians—	
(f.o.b. Leith)—Hartley Prime	13/– to 13/3
Secondary Steam	12/– to 12/6

ENGLAND.

Yorkshire, Manchester—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	13/– to 16/–
Northumberland, Newcastle—	
Blyth Best	13/9 to 14/3
„ Second	13/3 to 13/6
„ Best Small	10/6 to 11/–
Unscreened	12/6 to 13/6
Durham—	
Best Gas	14/8
Foundry Coke	19/– to 20/–

Sheffield—	Inland.
Best Hand-picked Branch	23/– to 25/–
South Yorkshire Best	20/– to 22/–
South Yorkshire Seconds	17/– to 18/–
Rough Slacks	8/– to 9/–
Nutty Slacks	7/– to 8/6

SOUTH WALES.

Cardiff— Steam Coals:	
Best Admiralty Large	19/6
Best Seconds	19/– to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Bunker Smalls	12/6 to 13/6
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/– to 26/–
Foundry Coke	27/– to 40/–
Furnace Coke	19/– to 22/6
Patent Fuel	21/–
Swansea—	
Anthracite Coals:	
Best Large	36/– to 40/–
Machine-made Cobbles	41/– to 48/6
Nuts	40/– to 48/6
Beans	25/– to 30/–
Peas	19/– to 23/–
Rubbly Culm	11/– to 11/6
Steam Coals:	
Large Ordinary	18/– to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

French Engineering Notes.

(From our own Correspondent in Paris.)

Mechanical Cultivation.

PROGRESS in the application of internal combustion engines to agricultural machines is dependent on the state of agriculture and the situation of farmers, who are willing to purchase machines when their industry is prosperous and neglect them during periods of unprofitable working when they have little money to spend on what they regard, at the moment, as superfluities. Yet the use of cultivating machinery is more necessary to farming economy in bad times than under normal conditions of production and prices, and manufacturers have generally profited from a depression in agriculture to introduce new machines that will help to bring down farmers' costs. The depression, however, has now reached a point at which agriculturists abstain systematically from buying machinery on the ground that the products of agricultural engineering are sold at rather more than the relative level of prices before the devaluation of the franc, while prices of agricultural produce have depreciated by 60 to 75 per cent. Until this discrepancy in price levels is reduced there can be little hope of a revived buying of machinery, and makers of tractors and motor tillage machines have, meanwhile, little inclination, and are for the most part unable, to incur the cost of building and experimenting with new machines. In these circumstances, the annual field demonstrations, held last week near Pontoise, lost a good deal of their usual interest; but they nevertheless emphasised tendencies in the design of cultivating machinery, partly in consequence of a higher fuel cost resulting from the State organisation of the home oil-refining industry. So long as fuel oil was obtainable at a low price the future appeared to centre upon the oil-injection engine, but its advantage of cheap running has been lessened by the taxation of fuel oil and the heavily increasing consumption of crude oil for steam raising, which tends to limit the supply of engine fuel under conditions of regulated imports. Nevertheless, economy in fuel consumption must remain a feature of the oil-injection-engined tractor, in which starting from cold is simplified by an automatic changing over from petrol to fuel oil, and notwithstanding their higher first cost there is no probability of British, French, and American tractors with oil-injection engines losing ground in the French market. On the other hand, a leading German maker of tractors has substituted the hot bulb engine for the compression-ignition system, which it was amongst the first to introduce, but that may be due to national economic causes, in the same way that engines on Hungarian and Italian tractors are usually of the hot bulb type. The French continue to perfect charcoal and wood suction gas plants for tractor engines, and one such tractor was shown on the grounds, although not in operation, that appeared to represent a notable advance in design, if the claims for the producer are substantiated. The designing and construction of motor tillage machines do not follow any general lines, for the reason that in a country where agricultural practice varies so considerably manufacturers are left much to their own initiative in producing machines for particular purposes, and there is no prospect yet of machines settling down to standard types. The use of electricity was regarded at one time as likely to place limitations on the internal combustion engine for tillage machines, but as high-tension mains cannot be installed in rural areas to supply current for ploughing during a very short period, the future of the tractor will find renewed popularity when agriculture emerges from the present crisis.

Wagon Builders' Union.

The International Association of Wagon Builders held its annual meeting in Paris last week, when arrangements were made for the admission of Great Britain and Germany as members, and the Union, after vegetating for some years, is now in a position to carry out its programme for the organisation of foreign trade in railway rolling stock, except locomotives. The original purpose of the Union was mainly commercial and provided for the centralisation and distribution of foreign orders, but the absence of Great Britain, the withdrawal of Germany, and the general disintegration of business, led the Union to confine itself to purely technical matters, such as supplying members with useful data when submitting tenders. The most serious trouble is the great diversity of foreign specifications, which it was hoped to simplify by drawing up more or less standard specifications based upon the general requirements of foreign railways and inducing them to adopt such standards in their own interests and in the interests of wagon builders. This work alone is of great importance to all builders of rolling stock, British and foreign, and now that practically the whole industry is united in carrying it out there is more prospect of its being able to influence foreign railway companies in adopting some form of standardisation.

Flood Reservoirs.

In view of the immediate construction of the third of the series of reservoirs which are to regulate the level of the river Seine by impounding water from its tributaries during times of flood and restoring it in seasons of drought, a commission of the Conseil Général de la Seine has visited Champaubert-aux-Bois, in the Haute-Marne, and inspected the site that is to be submerged to provide a lake 1400 acres in area and about 10 m. deep. Three dams will be made of clay having lengths respectively of 1385 m., 1280 m., and 490 m. The longest will be 18 m. high and 75 m. wide at the base. Each dam will have a core of puddled clay rammed to make it impermeable. The capacity of the Champaubert reservoir will be about 23 million cubic metres, which is the same as the combined capacities of the Crescent and Chaumeçon reservoirs that are already in service. The fourth reservoir to be put in hand is the Pannevière, which will have a capacity of 85 million cubic metres. These four reservoirs will supply the Seine with a million cubic metres a day for 100 days, and during floods will lower the level by 6in. to 8in., which, with the protection works already carried out, is expected to avert any danger of flood in the Paris area.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., 1s. each.

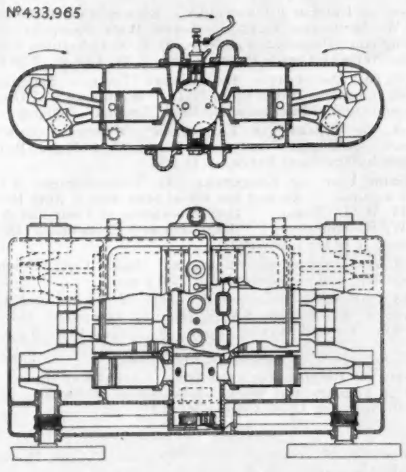
The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

433,965. March 5th, 1934.—OPPOSED PISTON ENGINES, V. C. E. Marten-Gwilliam, c.o. The Westminster Bank, Ltd., Southsea, Hants.

This is an extensive specification covering many constructional details, but the engine may be described generally as being of the eight-cylinder type, with opposed pistons, two

Nº433,965



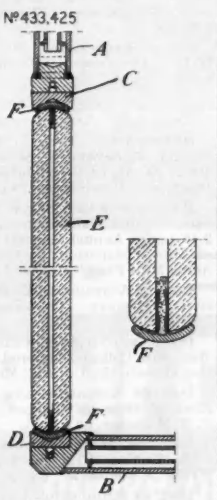
intergeared crankshafts and one rotary valve for the admission and exhaust to all the cylinders. The inventor says that the arrangement puts the valve in balance against the force of the explosions and greatly reduces rubbing friction.—*August 23rd*, 1935.

ELECTRICAL APPLIANCES.

433,425. January 30th, 1935.—RESISTANCE ELEMENTS FOR ELECTRIC FURNACES, Keramische Industrie-Bedarfs-A.-G., Berliner Str. 23, Berlin-Charlottenburg, Germany.

It is explained that in electric furnaces for firing ceramics, which may be worked at temperatures above 1400 deg. Cent., there is much trouble in maintaining proper electrical contact between the heating elements and their terminals. According to this invention, the terminals A and B are water cooled, as shown, and have replaceable contact pieces C and D. The heating element E has a central bore and is capped at the ends by heat-resisting metal pellets F F, which have stalks that are pressed into the bore and are secured by electrically conducting cement. The caps are of a smaller diameter than the heating element, so that the element can easily be passed through the opening in the furnace.—*August 14th*, 1935.

Nº433,425

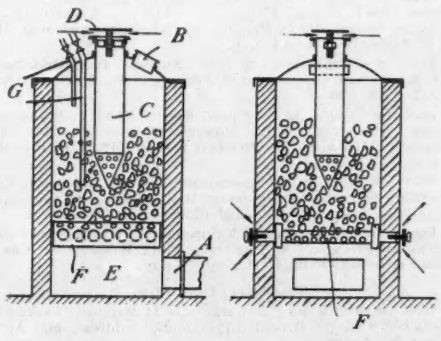


FURNACES.

433,551. February 16th, 1934.—FURNACES, F. I. E. Stenfors, Sundsvaal, Sweden.

It is claimed that this furnace will provide smokeless combustion with highly bituminous coal. It is of the down-draught type; that is to say, it is fed with both fuel and air from the top and the hot products pass downwards through the grate to

Nº433,551

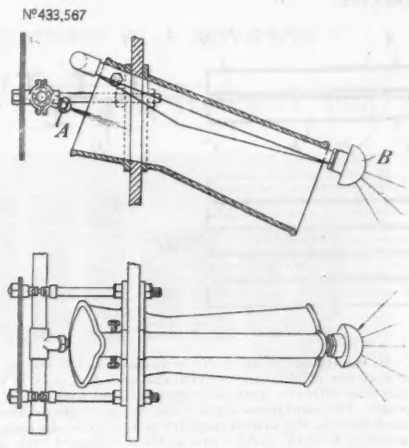


be drawn off for utilisation by the duct A. The fuel is charged in at B and air is supplied through the perforated pipe C. This supply is regulated by the valve D. Secondary air is supplied to the combustion chamber E through the hollow fire-bars F and additional liquid or gaseous fuel may be introduced by the pipes G. The height of the air pipe C can be regulated to suit the depth of the fuel bed.—*August 16th*, 1935.

433,567. May 11th, 1934.—CONTROLLING COMBUSTION IN FURNACES, H. A. Richardson, 12, West 56th-street, New York, U.S.A.

For the purpose of promoting combustion over the fuel bed of a boiler furnace the inventor introduces secondary air through passages of the type illustrated. These are directed downward on to the fuel bed and are of Venturi shape. A draught of air is

Nº433,567



induced through the passage by a steam jet A and the pressure of this air is not more than 5 lb. per square inch. A rose-like nozzle B is arranged at the mouth of the passage and is supplied with steam or air at a pressure of from 20 lb. to 500 lb. per square inch. The jets from this rose are all pointed more or less downwards on to the fire and help to entrain the incoming air.—*August 16th*, 1935.

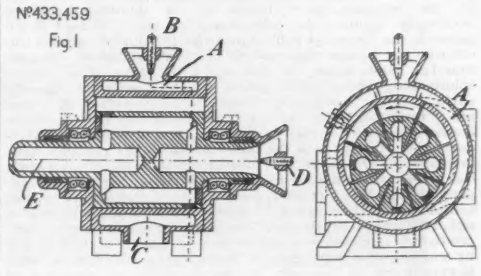
PUMPING AND BLOWING MACHINERY.

433,459. February 9th, 1934.—COOLING COMPRESSORS, EXHAUSTERS, &c., T. W. Nichols, 63, Capel-road, Forest Gate, London, E.7.

The inventor cools his compressor by means of an air jacket. This jacket is shown at A, and through it a draught is produced

Nº433,459

Fig.1



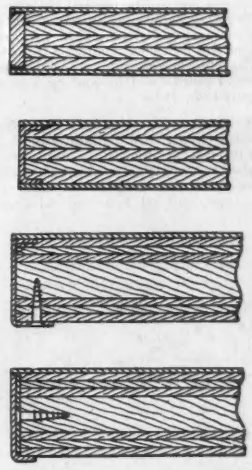
by the air jet B. Fins are cast in the jacket to make the air take a tortuous path, and it leaves by the outlet C. Another jet D induces a draught through the perforated rotor and out by the hollow shaft E.—*August 9th*, 1935.

BUILDING.

433,429. February 14th, 1935.—METAL-FACED BOARDS, Venesta, Ltd., and A. Love, Vintry House, Queen-street-place, London, E.C.2.

This invention relates to boards which may be wholly of solid wood or wholly of plywood or partly of solid wood and partly of plywood, which boards are faced on one or both sides with metal sheets. Such metal-faced boards may be

Nº433,429



adapted for various uses, such as panels, doors, or walls of various structures. According to the present invention, an edge or edges of such boards is or are protected by a metal strip, a longitudinal edge or longitudinal edges of which is or are attached to the inner face or faces of the metal sheets by soldering. Alternative methods of construction are illustrated.—*August 14th*, 1935.

433,558. February 20th, 1934.—FLOORS, BRIDGES, ROOFS, CEILINGS AND LIKE STRUCTURES, *O. Evans*, 27, *Chancery-lane, London, W.C.2.*

According to this invention, a rigid structure is provided for use in the construction of floors, bridges, roofs, ceilings, and the like, consisting of girder sections which are so disposed that the neutral or gravitational axis of each section is out of coincidence

with the neutral or gravitational axis of the structure, and in which the contiguous edges of the flanges of adjacent sections are rigidly secured together at positions disposed at or near the ends of the sections. Thus a considerable increase in the bearing strength and rigidity of the structure is obtained, the same amount of material being used as with known forms of structure.

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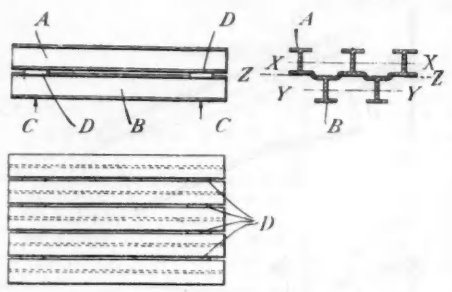

In the drawings the girder sections A and B are so provided that the neutral or gravitational axes X X and Y Y do not coincide with the neutral or gravitational axis Z Z of the structure. The contiguous edges of the flanges of the adjacently disposed sections are welded together at D near to the supporting positions C at the ends of the sections.—*August 16th*, 1935.

MISCELLANEOUS.

433,252. December 10th, 1934.—A Process for Producing Chlorinated Rubber and Product thereof, International Latex Processes, Ltd., 10, Lefebvre-street, St. Peter's Port, Guernsey, Channel Islands.

This invention relates to the production of chlorinated rubber in the form of a fine powder directly from rubber latex without the necessity for contaminating the product with large proportions of inert material and without the use of large proportions of rubber solvents which necessitate expensive recovery processes. Accordingly chlorine is introduced into a previously vulcanised latex, at least until a precipitation of discrete particles of a chlorinated rubber takes place. It has been found that the stabilisation produced by vulcanisation is not sufficient to produce a substantially chlorinated rubber in a truly dispersed condition, as are the original rubber particles in the latex. On the contrary, precipitation of the chlorinated rubber eventually occurs. As chlorination of the stabilised latex proceeds the dispersed rubber particles presumably absorb the chlorine and remain dispersed at least until sufficient chlorination has taken place, so that when the coagulation of the chlorinated rubber takes place a precipitation of discrete particles rather than a solid mass of coagulum is effected. After precipitation of these discrete particles of chlorinated rubber further chlorination may take place by continuing the introduction of chlorine into the liquid in which the particles have precipitated. However, it is found more convenient to separate the precipitated chlorinated rubber particles from any accompanying liquid by filtration, decantation, or like operation, and continuing the chlorination of these particles in a closed chamber either before or after drying. The following is an example of the production of chlorinated rubber powder from a latex stabilised by vulcanisation according to the invention. A normal latex having about 36 per cent. by weight solids is vulcanised by adding thereto 0·5 part of zinc oxide, 1 part of casein, 5 parts of precipitated sulphur, 0·5 part of mercaptobenzothiazole (accelerator) and 0·25 part of sodium dibutyl dithiocarbamate (accelerator), based on 100 parts by weight of dry rubber in the latex, and heating this mixture at 90 deg. Cent. for one and a-half hours. The addition of the casein or some other stabiliser to stabilise the latex during the vulcanisation is desirable, but may be dispensed with. In any case, after a vulcanisation has taken place, a latex of considerably greater stability than the unvulcanised rubber latex is produced. Chlorine is then bubbled into this vulcanised latex at atmospheric pressure. Considerable heat develops and the latex gradually thickens. Coarse flocculated particles soon appear and as the reaction develops these particles gradually separate. In the meantime the heat of the reaction has driven off a good part of the water and the remaining liquid is eliminated by filtering. The chlorination of the separated particles is continued until a white, powdery hard material is obtained. An analysis of this product shows 39·6 per cent. chlorine, 0·0 sulphur, and 0·31 per cent. ash. It is interesting to note that all of the sulphur from the vulcanisation has been eliminated by the chlorine. The desired chlorine content of the chlorinated rubber may be accomplished by continuation of the chlorination, to the desired extent, of the precipitated particles in the liquid or of the particles separated from the liquid after coagulation. The chlorinated rubber powder may be used in the manufacture of paints and in coating and moulding compositions.—*August 12th*, 1935.

433,561. April 27th, 1934.—Valves, Serk Radiators, Ltd., Warwick-road, Greet, Birmingham, and F. Robson.

This valve is intended primarily for use with oil coolers and filters and is of the two-way type, so that either one of two coolers can be put out of action for cleaning. As will be seen, the valves are of the plug type, and are operated simultaneously by the

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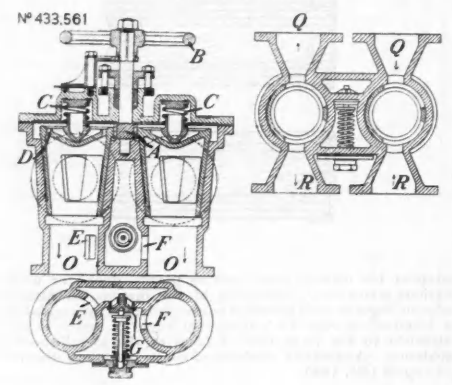

pinion A and hand wheel B. The plugs are kept down on their seatings by the springs C C, and the fluid pressure on their closed ends is balanced through the holes D. When such a valve mechanism is employed for controlling the flow of oil to a pair of oil coolers, the inlet pipe by which oil is conveyed to the coolers is connected to one of the openings O in the body part, and the outlet pipe which conveys oil away from the coolers is connected to the other opening. The side passages Q R controlled by one of the plugs are respectively connected to the inlets of the two coolers, and the outlets from the two coolers are connected to the side passages Q R controlled by the other plug. The openings E F and the valve G provide for the release of excessive pressure.—*August 16th*, 1935.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

To-day.

Inst. of British Foundrymen: Birmingham, Coventry, and W. Midlands Branch.—James Watt Memorial Inst., Birmingham. Presidential address, Mr. G. M. Callaghan. Paper, "Some Notes on Cupola Practice," Mr. L. W. Bolton. 7.30 p.m.

Inst. of Production Engineers: London Section.—British Industries House Club, W.1. "Manufacture of Optical Glass and Optical Instruments," Mr. F. Loewen. 7.30 p.m.

Inst. of Structural Engineers: Western Counties Branch.—Merchant Venturers' Technical College, Bristol. Address by Dr. Oscar Faber. 7.15 p.m.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. Short lectures: "Around the Royal Mint with a Note Book," Mr. H. W. L. Evans; "The Importance of Craftsmanship," Mr. W. H. Ballantyne; "Engineers and Economics," Dr. H. Chatley. 7.15 for 7.30 p.m.

Keighley Assoc. of Engineers.—Kiosk Café, Keighley. Whist drive and social evening. 7.30 p.m.

Physical Soc.—At Imperial College of Science and Technology, S. Kensington, S.W.7. Editing Committee meeting, 3.30 p.m.; Council meeting, 4 p.m.; meeting, 4.45 for 5 p.m.

Saturday, Oct. 5th.

Inst. of British Foundrymen: Lancashire Branch.—Visit to Foundry and Works at Daisyfield, Blackburn, of the British Northrop Loom Company. 2.15 p.m.

Monday, Oct. 7th.

Bradford Engineering Soc.—Technical College, Bradford. Presidential address, Mr. F. Peacock. 7.30 p.m.

Inst. of Mechanical Engineers: Graduates' Section.—Storey's-gate, St. James's Park, S.W.1. "Early Gearing," Mr. R. Wailes. 6.45 p.m.

Inst. of Production Engineers: Sheffield Section.—At the Royal Victoria Station Hotel, Sheffield. "Stainless Steels," Dr. W. H. Hatfield, F.R.S. 7.30 p.m.

Inst. of Structural Engineers: Midland Counties Branch, Junior Members' Section.—James Watt Memorial Inst., Birmingham. Chairman's address, Mr. A. L. Percy. 6.30 p.m.

Soc. of Engineers.—At Geological Soc., Burlington House, W.1. "The Future of Transport," Mr. C. R. Enock. 5.30 for 6 p.m.

Tuesday, Oct. 8th.

Engineers' Club, Manchester.—Annual Dinner Evening.

Illuminating Engineering Soc.—At Lighting Service Bureau, 2, Savoy-hill, Strand, W.C.2. Presidential address, Mr. A. W. Beuttell; Exhibits, Demonstrations, and Report on Progress in Illuminating Engineering. 4.30 p.m.

Manchester Geological and Mining Soc.—Queen's Chambers, 5, John Dalton-street, Manchester, 2. Council Meeting: 2.45 p.m. Annual General Meeting. Paper: "Some Aspects of Mine Ventilation Embodying Practical Experience with Aerex Mine Fans," Messrs. A. G. and J. R. D. Walker 3.30 p.m.

Inst. of Automobile Engineers.—At Geisha Café, Hertford-street, Coventry. Presidential address, Mr. A. J. Hancock. 7.30 p.m.

Inst. of British Foundrymen: Lancashire Branch.—Municipal College, Ormerod-road, Burnley. "Some Visits to Foundries in the U.S.A.," Mr. T. Makemson. 7.15 p.m.

Inst. of Engineers and Shipbuilders in Scotland.—39, Elmbank-crescent, Glasgow, C.2. Presidential Address, Prof. P. A. Hillhouse. 6 p.m.

Inst. of Marine Engineers.—85, The Minories, E.C.3. "The Testing of Engineering Materials," Dr. H. J. Gough and Mr. W. J. Clenshaw. 6 p.m.

Inst. of Production Engineers: Coventry Section.—At the New Technical College, The Butts, Coventry. "Engineering Conditions in Russia," Mr. A. Monkhouse. 7.30 p.m.

Sheffield Metallurgical Assoc.—198, West-street, Sheffield, 1. Extraordinary general meeting, 7 p.m. "Rolling of Steel," Mr. H. Williams. 7.30 p.m.

Wednesday, Oct. 9th.

Inst. of Automobile Engineers.—Metropole Hotel, Leeds. Presidential address, Mr. A. J. Hancock. 7.15 p.m.

Inst. of Chemical Engineers.—At Burlington House, Piccadilly, W.1. "Modern Methods of Welding," Mr. C. H. Davy. 6 p.m.

Inst. of Civil Engineers: Manchester and District Assoc.—In Rooms of Manchester Library and Philosophical Soc., 36, George-street, Manchester. Chairman's address, Mr. G. E. Ashforth. 6 for 6.45 p.m.

Inst. of Engineers-in-Charge.—St. Bride Inst., Bride-lane, E.C.4. "Plant Pipework and Fittings," Mr. A. G. Bugden. 6.30 for 7.30 p.m.

Inst. of Fuel.—At Geological Soc. of London, Burlington House, Piccadilly, W.1. Presidential address, Sir John Cadman. 11.30 a.m. The Melchett Lecture, Mr. H. R. Ricardo, F.R.S. 2.30 p.m.

Inst. of Production Engineers: Luton, Bedford and District Section.—Castle-street Hall, Luton. "Engineering Conditions in Russia," Mr. A. Monkhouse. 7.30 p.m.

Inst. of Structural Engineers: Lancashire and Cheshire Branch.—At Engineers' Club, Manchester. Chairman's address, Mr. W. B. McKay. 7 p.m.

Thursday, Oct. 10th.

Inst. of Automobile Engineers.—At Merchant Venturers' Technical College, Bristol. Presidential address, Mr. A. J. Hancock. 7 p.m.

Inst. of Metals.—At Soc. of Motor Manufacturers and Traders, 83, Pall Mall, S.W.1. Chairman's address, "Gases and Metals," Dr. C. V. Smithells. 7.30 p.m.

Inst. of Mechanical Engineers: North-Western Graduates.—Engineers' Club, Manchester. Annual lecture, "Engineering Progress and Development," Mr. R. W. Bailey. 7.15 p.m.

Inst. of Metals: London Local Section.—In the Rooms of the Society of Motor Manufacturers and Traders, Ltd., 83, Pall Mall, S.W.1. Chairman's address, "Gases and Metals," Dr. C. J. Smithells. 7.30 p.m.

Manchester Assoc. of Engineers: Students' Section.—Y.M.C.A., Peter-street, Manchester. Chairman's address, Mr. N. L. G. Lingwood. 7.30 p.m.

Friday, Oct. 11th.

Inst. of British Foundrymen: Middlesbrough Branch.—In Cleveland Scientific and Technical Inst., Corporation-road, Middlesbrough. Presidential address, Mr. A. Scholes. Reception, whist drive, and dance. 7.45 p.m.

Chemical Engineering Group.—Burlington House, Piccadilly, W.1. "Some Chemical Engineering Problems in the Manufacture of Papermakers' Cellulose," Dr. J. L. Macdonald. 8 p.m.

Inst. of Metals.—In Non-ferrous Section of Applied Science Dept. of University, St. George's-square, Sheffield. "Lead Mining in Derbyshire," Mr. L. B. Williams. 7.30 p.m.

Inst. of Mechanical Engineers.—Storey's-gate, St. James's Park, S.W.1. Informal meeting. Exhibition of films, with technical commentary, descriptive of the Vickers Works of the English Steel Corporation. 7 p.m.

Inst. of Sanitary Engineers.—Chiltern Hall, Baker-street, W.1. Opening sessional meeting. 7.30 p.m.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. Chairman's address, "Bleaching and Finishing of Cotton Cloth," Mr. H. P. Wright. 7.30 p.m.

Manchester Assoc. of Engineers.—Engineers' Club, Manchester. Presentation of awards. Presidential address, Mr. J. A. Thornton. Smoking concert. 7.15 p.m.

Railway Club.—At Royal Scottish Corporation Hall, Fetter-lane, E.C.4. "Some Famous British Railway Accidents," Mr. H. W. Bardsley. 7.30 p.m.

Friday and Saturday, Oct. 11th and 12th.

Inst. of British Foundrymen: London Branch.—Joint meeting with East Midlands Branch. Friday, visit to works of Leys Malleable Castings Company, Ltd. Saturday, at Loughborough College, Loughborough. "Is Foundry Mechanisation Worth While?" Mr. L. G. Tibbenham; "Strength and Fluidity in Cast Iron," Mr. H. Bunting. 9.45 a.m. Afternoon inspection of Loughborough College.

Saturday, Oct. 12th.

Inst. of Marine Engineers: Junior Section.—85/88, The Minories, E.C.3. Dance, 7.30–11.15 p.m.

Monday, Oct. 14th.

Inst. of Metals: Scottish Local Section.—Visit to Henry Wiggin and Co., Ltd., Zenith Works, Thornliebank, Glasgow. 7.30 p.m.

Inst. of Transport.—At Inst. of Electrical Engineers, Savoy-place, Victoria Embankment, W.C.2. Presidential address, "Progress in the Co-ordination of Transport in Great Britain," Sir Cyril Hurcomb. 5.30 p.m.

Tuesday, Oct. 15th.

Assoc. of Supervising Electrical Engineers.—At E.L.M.A. Lighting Service Bureau, 2, Savoy-hill, W.C.2. Presidential address. 7.15 p.m.

Inst. of Locomotive Engineers.—At the Literary and Philosophical Soc., 36, George-street, Manchester. Presidential Address, Mr. A. C. Carr. 7 p.m.

Inst. of Production Engineers: Edinburgh Section.—North British Station Hotel, Edinburgh. "Measurement and Control of Surface Roughness," Mr. H. Shaw. 7.30 p.m.

Inst. of Transport.—At Inst. of Electrical Engineers, Savoy-place, Victoria Embankment, W.C.2. "Transport in the Dominions," Mr. A. W. Arthurton. 5.30 for 6 p.m.

Sheffield Metallurgical Assoc.—198, West-street, Sheffield, 1. "The Testing of Steel Foundry Sands and its Practical Utility," Mr. T. R. Walker. 7.30 p.m.

Soc. of Chemical Industry: Plastics Group.—Stewart's Restaurant, Piccadilly, W.1. Informal dinner, 6.45 for 7 p.m. Burlington House, Piccadilly, W.1. "What the Architect Requires of Plastic Materials," Mr. G. Wornham. 8 p.m.

Wednesday, Oct. 16th.

Inst. of Civil Engineers: Birmingham and District Assoc.—Visit to works of the South Staffordshire Waterworks Company.

Inst. of Civil Engineers: Manchester and District Assoc.—In Rooms of Manchester Library and Philosophical Soc., 36, George-street, Manchester. "Sand and Gravel as Engineering Materials," Mr. A. B. Searle. 6 for 6.45 p.m.

Inst. of Production Engineers: Birmingham Section.—At James Watt Memorial Inst., Birmingham. "Optical Measuring Instruments," Mr. F. Loewen. 7.30 p.m.

Inst. of Production Engineers: Southern Section.—At University College, Southampton. "Modern Trend in Piston Ring Design," Mr. F. Blakith. 7.30 p.m.

Inst. of Structural Engineers: Scottish Branch.—At 129, Bath-street, Glasgow. Chairman's address, Mr. A. S. Kinnear. 7.15 p.m.

Newcomen Soc.—In Hall of the Chartered Inst. of Patent Agents, Staple Inn-buildings London, W.C.1. Presidential address, "The Germs and Development of some Mechanical Inventions," Mr. C. F. Dendy Marshall. 5.30 p.m.

Thursday, Oct. 17th.

Inst. of Automobile Engineers.—At the Park-lane Hotel, Piccadilly, W.1. Annual dinner. 7.30 for 8 p.m.

Inst. of Marine Engineers.—85/88, The Minories, E.C.3. "Recent Developments in Ship Forms, including Rudders," Mr. T. R. Thomas. 7 p.m.

Inst. of Production Engineers: Glasgow Section.—At the Inst. of Engineers and Shipbuilders in Scotland, Elmbank-crescent, Glasgow. "Measurement and Control of Surface Roughness," Mr. Harry Shaw. 7.30 p.m.

Thursday, Oct. 17th, to Saturday, Oct. 26th.

Society of Motor Manufacturers and Traders, Ltd.—Twenty-ninth International Motor Exhibition, Olympia. Open daily (except Sundays).

Friday, Oct. 18th.

Inst. of British Foundrymen: Middlesbrough Branch.—In Cleveland Scientific and Technical Inst., Corporation-road, Middlesbrough. "A Talk on the Production of Steel Castings," Mr. J. G. Wrightson. 7.45 p.m.

Inst. of Mechanical Engineers.—Annual Dinner, Connaught Rooms. 6.45 for 7.5 p.m.

Inst. of Production Engineers: London Graduate Section.—At British Industries House, W.1. Presidential address, "Tooling for the Small Shop," Mr. W. G. Carr. 7.30 p.m.

Inst. of Production Engineers: Western Section.—In Common Room, Merchant Venturers' College, Bristol. "Optical Measuring Instruments," Mr. Franz Loewen. 7.15 p.m.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. Informal meeting. "The Thames Barrage," Mr. J. H. O. Bunge. 7.30 p.m.

Manchester Technology Old Students' Assoc.—In College of Technology, Manchester. Film, "The Laying of the Iraq Pipe Line," Dr. A. E. Dunstan. 7.30 p.m.